



The Blast Furnace and Steel Plant

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Control of Temperature in The Acid Bessemer Blow

The Methods for Raising the Temperature Are Considered in Detail—Means for the Control of Temperature Stated Collectively and Described.

By HENRY D. HIBBARD

IN the Bessemer process the importance of having the proper temperature of the charge throughout from start to finish, is well known, but the reason or reasons for such regulation is only partially known. The range of temperature must be between the point, on the low side, that will keep the metal and slag sufficiently fluid and the point on the high side that will permit or cause the chemical reactions of the process to take place in their proper order and manner. Control of the temperature also enables the gases to be dealt with correctly, so that they shall be within an allowable maximum in quantity, if solution or killed steel is being made, and in ample supply if the product is to be low-carbon effervescing or "rimming in" steel. The temperature of dissociation of the silicon oxide must not be reached, on the high side, for if that occurs the silicon will not be wholly oxidized and the residual silicon will be high and uncertain in amount, that is, anything up to 1½ per cent, while the drop of the carbon flame at the end will be obscure and difficult to determine. In such steel the gases cannot be controlled and the ingots or castings are likely to be infested with gas holes. The casting temperature in particular must be right within narrow limits; the ideal degree for most ingot steels being that at which the steel may be cast cleanly into the molds, with the formation of an embryo skull left in the ladle, the smaller the skull the better, but in any case not large enough to cover the ladle bottom. For steel castings the steel should be hotter and leave no skull.

The normal course of temperature for a Bessemer blow is only to be learned by experience. Indications come early in the blow, during the first period, when the silicon is being burnt, which tell the experienced blower whether to take measures to raise or lower the temperature or to "stand pat." The chief indication is the smoke which appears on the edges of the flame. The earlier the smoke appears and the more there is of it, the hotter the charge will tend to become and vice versa. The proper amount of smoke which cannot be described in words, is soon learned in practice. Within three or four minutes from the beginning of the blow one may tell if the

heat will require to be warmed or cooled, if either.

Assuming that the composition (as usually understood) is correct, the quality and fitness of the steel for its intended purpose depends then largely on the temperature of the blow. Aside from the effect of temperature on the gases, the reason or reasons why too high a casting temperature gives inferior quality to the product is not wholly known although they seem to be closely connected with the crystallization, the inter-crystalline matter, and perhaps the non-metallic matter or inclusions (sonims) contained.

The means for the control of temperature are the subject of this article. It is the writer's opinion that they have never been stated collectively before and some of them are now described for the first time. Methods for obtaining hotter metal are first considered and those to cool the metal later. Some of these procedures may be applied to a heat during blowing while most of them cannot, but may be resorted to for future blows.

The methods for raising the temperature which will be considered in detail are:

1. Have metal of the charge hotter before it enters the vessel.
2. Have more silicon in the metal of the charge.
3. Have more manganese in the metal of the charge.
4. Make the depth of the molten metal in the vessel greater.
5. Raise the blast pressure.
6. Have smaller holes in tuyeres, if too large.
7. Add high-silicon-iron alloy.
8. Blow with vessel tipped part way.
9. Dry the air-blast.
10. Make linings and bottoms more durable.
11. In general run faster.

The first thing to be done is to ascertain the cause of too low temperature, which, however, may demand much study. Once that is found the proper cure may be selected and applied.

The first heat after lining or repairing a vessel is likely to lack the proper temperature unless means are employed to prevent it. The easiest way, provided vessel and ladle are well dried and heated red

hot, is to have an additional half per cent of silicon in the crude iron of the charge.

1. *Have Charge Hotter Before It Enters the Vessel—*

This is the obvious cure but it cannot, of course, be applied to a heat which is found to be blowing too cold. For steady work it is naturally the thing to be done as it has been well said that coke is cheaper than silicon. When the iron is melted in a cupola more fuel (coke) per ton must be charged therein per ton of iron in order to have the molten iron hotter. For instance, if, with a given rate of running, 10 pounds of iron have been melted with one pound of coke and the metal comes too cold, increasing coke to one-eighth of the weight of the iron will give distinctly hotter metal.

When, however, direct iron is blown, which is usually passed through a mixer, the initial temperature of the metal of the charge is less under control even though the mixer be "active," that is, designed for substantial quantities of fuel to be burned therein like an over-sized open hearth furnace. With a mixer, the practice should be laid out so as to have blows sufficiently hot without dependence on surplus heat in the iron of the charge.

2. *Have More Silicon in the Charge—*This is the

In this article the author, who is one of the foremost authorities on the Bessemer process, describes difficulties which occur regularly in making Bessemer steel. He then explains how these difficulties can be either avoided or afterwards adjusted. The observations described in this article have never before been collectively written.

usual well known expedient. The efficacy of silicon in this respect lies in its great calorific power (1 kilogram burnt by oxygen giving 7,595 calories), and also in the fact that the product of its combustion, SiO_2 , is not gaseous and therefore, remains with all its heat of generation within the vessel, while gases which escape from the vessel carry off heat. The percentage of silicon required varies in a general way from about one per cent, in iron to be made with continuous running into ingots in a 15-ton vessel, to 2 per cent in iron to be made into castings (which require hotter steel) in a 3-ton vessel. These percentages may, of course, be changed somewhat by the other controlling causes considered hereafter. The percentages of silicon mentioned are for the charge actually entering the vessel. If steel scrap forms a part of the cupola charge and so dilutes the silicon, the pig iron must contain proportionately more silicon. The larger the vessel, generally speaking, the lower may be the percentage of silicon in the crude iron because of the smaller radiating surface per unit of capacity. In summer when the air contains more moisture than in winter, higher silicon (say 0.2 per cent) is usually needed to make up for the cooling effect of that moisture in the blast. More silicon in the metal requires more air blown in per pound of charge.

3. *Have More Manganese in the Charge—*Manganese, unless, extremely high (say over 3 per cent), is usually entirely oxidized during the blow. Though it has not near the calorific power of silicon (1,653

calories as compared with 7,595 for silicon) it acts as a heat-giving element and may be used to give higher vessel temperatures. The calorific power of manganese does not, however, seem to account wholly for its charge-heating power, which is considerable. That calorific power is but little greater than that of iron of which one kilogram gives 1,612 calories when burned to magnetic oxide (Fe_3O_4). Some iron is always burned during the blow and the manganese merely replaces a part of that, as shown by the fact that the presence of manganese in the moderate proportions herein mentioned does not increase the percentage of loss of the whole charge. In heat-giving effect in the blow, 4 or 5 pounds of manganese is equivalent to about one pound of silicon.

No increase in volume of air blast per pound of charge is required by increase of manganese. The reason for this fact, as well as that mentioned above, namely that the waste is not increased by higher manganese in that charge, is that the manganese protects from oxidation an equivalent of iron which would otherwise be burnt and which, if burnt, would require as much oxygen (air), as the manganese which protects it. The oxidized manganese replaces an equivalent of iron in the slag. Silicate of manganese is formed which is easily fusible.

Manganese must, however, if used, be added in proper proportion to avoid certain slag troubles. If more than 0.75 per cent and less than 1.25 per cent is present the slag is likely to be thrown out of the vessel. With low manganese (say 0.2 or 0.3 per cent) the slag is likely to be partly liquid and partly solid so that it collects in balls to some extent during blowing, and sometimes gathers in "kidneys" on the sides of the vessel which accretions require to be cut away with hammer and wedge each week-end. With higher manganese (0.75 to 1.25 per cent), the slag is fluid but very thick and sometimes it forms leathery sheets which impede the blast momentarily only to be blown out of the vessel's nose the next instant by the increased pressure of the pent-up air of the blast. This may occur repeatedly until most of the slag, with considerable of the iron, is thrown out, the whole operation being very sloppy and the loss or waste of iron unduly high. With still higher manganese, say 1.25 to 1.50 per cent the slag will be so fluid that it gives no trouble of that sort. The extremely fusible silicate of manganese formed accounts for these effects on the slag.

With 2.2 per cent of manganese and 0.7 per cent of silicon in the metal, heats have been blown with less than 5 cubic feet of air per pound of charge, which is unusually low. A charge in a 3-ton converter may blow hot enough with one per cent of silicon and 1.75 per cent of manganese while with low manganese nearly 2 per cent of silicon would be required.

Increased manganese generally causes increased smoke in the flame issuing from the vessel. This must be kept in mind in judging whether the temperature promises to be right or not.

4. *Make the Depth of Molten Metal in the Vessel Greater—*This procedure is, of course, predicated on the depth being too small in which case more of the oxygen of the air blown in will escape unburnt than should do so, and consequently the quantity of air entering the vessel will be unduly great. The unused excess carries off heat, escaping as it does at the vessel temperature, and thus cools the vessel interior and thereby the charge. A 3-ton vessel in which the

depth of metal was 11 inches gave steel too cold for small castings even when the silicon was 2.2 per cent. It was lined up thicker, so that the well was narrower and the charge was 14½ inches deep, with the result that the metal blew hot enough with only 1.75 per cent of silicon. The proper depth of the metal does not vary proportionately with the size of the charge as 16 inches has been found suitable for an 18-ton vessel. The depth should bear a proper relation to the size of the tuyere holes and the blast pressure as noted below, the correct depth being that which will cause practically all the oxygen in the air of the blast to be consumed.

5. *Raise the Blast Pressure*—This, of course, increases the volume of air per minute entering the vessel, and calls for increased speed of the blowing engine. It tends to shorten the time of blowing which lessens the loss of heat by radiation and otherwise. It thereby tends to increase the temperature of the blow. If, however, low temperature has resulted from insufficient depth of bath, raising the blast pressure will be a cooling rather than a heating variation. The case requires correct diagnosis before raising the blast pressure should be tried, or it may have the opposite effect of that intended.

6. *Have Smaller Holes in Tuyeres*—This variation, of course, implies that the holes in use are too large. In that case, making the jets of air smaller by the employment of smaller holes gives the oxygen of the air blast more chance to be completely consumed. It is a means of correcting the low temperature resulting from too shallow a bath. Thus ½-inch holes were found to be too large in a 3-ton vessel and were replaced by ⅜-inch holes, which caused the heat to blow hotter. The size of the holes should bear some relation to the depth of the bath. Half inch holes are sometimes used when the depth of bath is about 16 inches though even then a smaller diameter of tuyere-holes might give better satisfaction by a better control of the temperature.

7. *Add High Silicon-Iron Alloy*—This practice is of course merely adding more fuel, the combustion of which adds heat and so raises the temperature. If the silicon alloy or ferro-silicon is added cold, as is usually the case, the percentage of silicon in it should be over 14 per cent as the silicon by its combustion has to furnish heat for both melting and raising to the bath temperature the whole quantity added, before any heat is available for raising the temperature of the charge. Thus the thermal effect of adding 100 pounds of 14 per cent ferro-silicon to a 10,000 pounds converter charge is as follows:

$$100 \times 400 = 40,000 \text{ cals. to melt addition.}$$

$$14 \times 7595 = 106,330 \text{ cals. from combustion of silicon.}$$

$$\text{Surplus heat} = 66,330 \text{ cals.}$$

Surplus heat per pound of charge 6.6 calories, which will raise charge temperature about 30 degrees C. 400 is approximately the number of calories to melt and raise a pound of cold iron to the bath temperature. 7595 is the number of calories from burning one pound of silicon by oxygen. 33 degrees C. is a perceptible and important amount. In fact addition of less than 100 pounds (50 pounds) are common to a 10,000 pound charge. The additions, of ferro-silicon to a charge, while blowing, is chiefly a procedure followed in making steel for castings, for which extremely hot steel may be required, particularly if the castings to be made are small or thin. It is one of the methods which may be followed with a heat while it is blowing. The individual pieces of silicon alloy

should be small, not over 5 pounds weight each, so that they may be quickly melted and oxidized.

8. *Blow With the Vessel Tipped Part Way*—Doing this brings some of the tuyere holes above the molten charge and the blast from some of the others blows through the metal where it is shallow. There is therefore an excess of oxygen above the bath which burns some of the carbonic oxide gas (CO, which is the combustible gas given off during the second period) to carbonic acid (CO₂) and also burns some of the iron to oxide, both of which actions generate additional heat within the vessel and raise the charge temperature. This may be continued during the latter half of the blow. Side-blowing wastes more iron than normal blowing and the practice should be avoided as much as possible. Its good point is, that it may be applied to any single heat during blowing, and when it is too late to employ any other means, except perhaps the addition of ferro-silicon which, because of the high cost of the alloy, is not ordinarily used in making ingot steel. Hence, side-blowing is rarely used for any but ingot steel. It is the second method which may be employed with a heat while blowing is going on.

9. *Dry the Blast*—This plan proposed by Gayley, has been tried as an experiment but was given up because (it was announced) the bath temperature was raised in a harmful and uncontrollable way. At that time, steel scrap was worth more than pig iron (about in proportion to its iron Fe content) and its use in the large proportion that was indicated as being needed, appeared to be uneconomical. It raised rather than lowered the cost of the product when the cost of drying the air of the blast was included. At present prices such an objection would not hold to the same extent, and drying the blast looks like a promising development for the future.

10. *Make Linings and Bottoms More Durable*—By accomplishing this the quantity of material melted and scorified from the lining and bottom is lessened and therefore less heat will be absorbed in melting and raising it to the bath temperature, and in heating the freshly exposed refractory material. In this matter each plant must work out its own salvation. No two have the same materials at hand, at the same cost, due to differences in freight rates. All the likely bricks, clays and ganisters within reach should be tried, and those adopted which are found to be best suited to the particular practice maintained.

11. *Run Faster*—Aside from the conditions mentioned which make for faster running, the essential feature to accomplish it is to avoid or cut out all lost time. Time between blows and time taken for changing bottoms between blows and time taken for changing bottoms should be cut short. Nothing should have to wait for the next preceding thing to do its part or the next succeeding thing to "carry on". Thus after a heat is poured from the vessel to the ladle, the next heat should be ready in its ladle and be at once poured into the vessel. This metal ladle must have received its charge from the mixer long enough beforehand, that it may be hauled to the converter and be ready for the charge to be poured in, as soon as the vessel reaches the charging position. This is easy to say but efficient administration is called to keep up this sequence of motions. For the whole works this extends from the receipts of ore to the shipment of finished goods, assuming that the field of operations at the works in question is that broad. The record is not broken by feverish haste but by cool forethought that things which might prove hindrances are avoided. It is,

of course, by lessening the time for heat losses by radiation, conduction and convection that faster running tends to give hotter steel. Some of the methods hereinbefore described for having hotter heats make for faster running and therefore for larger output particularly numbers 1, 4, 5 and 10, as may be recognized on reflection. Thus, hotter metal (1) requires less silicon and less silicon requires less air and shorter time of blowing which, of course, permits more blows to the turn and therefore greater output. Similarly, the greater depth metal (4) lessens the silicon required with the same result. Raising the blast pressure (5) and more durable linings and bottoms (10) also by saving time increase output.

The use of greater depth of bath, smaller tuyere holes, lower silicon and 1.75 per cent manganese in the charge collectively effected a decrease in the volume of air blast required from $7\frac{1}{2}$ cubic feet per pound of charge to less than 6 cubic feet and shortened the time of blowing from 15 to 12 minutes.

Next we will consider the means which may be employed when heats are wanted to be cooler. Some of these are naturally in a general way the opposite courses to those laid down for enhancing the charge temperature. Such are numbers 1, 2, 3, 4, 5, 6, 10 and 11. Of these only the first three should ordinarily be considered. No. 2, diminishing the percentage of silicon in the metal, is the principal one resorted to before the charge reaches the vessel. Sometimes, however, less coke for melting or less manganese in the metal may be adopted, if the practice has been to use them too freely. Some methods are, however, peculiar for avoiding too hot heats. Those demanding consideration here are:

1. Have less silicon in the charge.
2. Add cold iron or steel scrap or washed metal.
3. Blow steam into the blast.

1. *Decrease Silicon*—This decreases fuel and therefore the heat supply. The temperature of the charge during the blow is not decreased in proportion as the silicon in the metal is diminished, because (1), the volume of air blast required per pound of charge is lessened and so the quantity of heat carried off by the escaping nitrogen is less, (2) the time of blowing is shortened and the loss of heat by conduction and radiation proportionately diminished. Unless these are allowed for, the first diminution of silicon for the purpose of having the heats blow colder may not have in full, the desired effect.

2. *Add Cold Iron*—This cold iron may be in the form of steel scrap or pig iron (not high in silicon preferably) or washed metal (which is always practically free from silicon). The cooling effect of such additions is obvious as they absorb heat in being melted and raised to the bath temperature. The additions are made to the charge in the vessel while it is being blown, and as soon as indications have appeared that the temperature threatens to become too high. The addition of 100 pounds of soft steel scrap to a 10,000 pounds charge cools it about 16 degrees C.

$$\frac{100 \times 400 \times 1600}{10,000 \times 400} = 16 \text{ degrees}$$

1600 degrees C. is assumed as the temperature of the blown iron. 400 is approximately the number of calories to bring one pound of cold iron up to bath temperature.

An experienced man can tell within a hundred pounds how much scrap a 5-ton blow should have added, which means that he can control the temperature of the metal within 16 degrees C., a very important fact.

The usual practice in making ingot steel is to have the conditions as to the initial temperature, percentage of silicon, etc., such that the tendency is for the heats to blow too hot, and then to add scrap to cool them to the proper degree. This puts the scrap added into ingots practically without cost. When castings are being made the desired temperature is aimed at initially and additions to heat or cool are made as developments indicate them to be needed.

3. *Blow Steam Into the Air-Blast*—Steam is water and water is the universal cooler so it is a sure cure for a heat that is blowing too hot. Whether or not it is detrimental to the quality of the steel is still an open question. The steam (water) is decomposed in part at least by the molten iron which combines with its oxygen and sets free its hydrogen. This latter is not desired in steel because of its part in the formation of gas holes and the oxide of iron formed is so much waste. Still steam is employed in blowing ingot steel, though not for castings, as far as known to the writer.

As in the case of heats blowing too cold, those blowing too hot should be correctly diagnosed before treatment is prescribed.

MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The 1921 spring meeting of the American Society of Mechanical Engineers is to be held in Chicago, May 23 to 26, at the Congress Hotel.

Well developed programs will be presented by the professional divisions of the society devoted to forest products, fuels, machine shop, management, material handling, power, railroad, and a specially important session will be devoted to training for industries. The Chicago committee, jointly with the Western Society of Engineers, is preparing a session on "Chicago as the Rail-Water Gateway."

Visits to a great number of points of engineering interest in Chicago will be arranged. Special attention is being given to the co-relation of plant visits with the technical sessions.

En route to the meeting, the society, jointly with the Society of Automotive Engineers, will stop at McCook Field on Saturday, May 21, for an inspection of the facilities of the field.

On May 27-28, the Friday and Saturday following the meeting, a joint excursion with the Army Ordnance Association will proceed to Rock Island arsenal, where the Ordnance Division will present papers and enjoy an inspection of the plant. Saturday will be devoted to a handicap golf tournament on the Rock Island links.

ORDNANCE DIVISION.

Preparedness is largely a problem for the engineer. That this matter should have constant attention on the part of the mechanical engineer, as the engineer of the industry, is well understood.

The opening activity of the Ordnance Division of the A.S.M.E. will consist of an excursion to Rock Island arsenal with the Army Ordnance Association on May 27-28, the two days following the A.S.M.E. spring meeting in Chicago. This excursion is limited to members of the two organizations who are citizens of the United States not engaged in the manufacture of munitions for foreign governments.

Mechanical Handling of Steel Mill Material

A General Description of Modern Methods Employed by Steel Mills in Handling Materials—Economy and Increased Tonnage Are Obtained.

By C. F. POPPLETON.

THE modern steel industry has advanced so rapidly even our fathers would hardly recognize a plant of today. Mechanical equipment that was looked upon as "faddy" even as recently as 15 years ago, is now an absolute necessity, that is if the plant is able to compete for business in the open market.

The purpose of this article is to show briefly the main lines of demarkation, between the practice which was followed by the pioneers of the industry in the United States and the practice that is necessary for the economic operation of a present day steel plant.

The logical place to start is at the stock yard. Within quite recent years the necessary materials, ore, coke and limestone were unloaded by hand from the railroad cars (these cars were run of service cars and not specially designed cars for steel works service as at present) and piled in a more or less haphazard manner in the space allotted for stock. From these piles the stock was loaded by hand into wheel-barrows and wheeled to the hoist at the foot of the furnace stack. The old-fashioned hoist consisted of a vertical tower, usually of channels and angle framework which formed at the same time guides and support for the cages. The stock was then raised by means of cages to the top of the furnace.

Charging a Blast Furnace.

For those of our readers who are not familiar with the method of charging a blast furnace it will be well to describe the operation. The top rigging of the furnace consists of two bells, one much larger than the other. These bells are cone shaped castings, and are suspended one below the other; the large bell being underneath. The vertical shaft supporting the top or smaller bell is hollow and the larger bell support is operated inside of it. The bells are arranged with the points of the cones upward, and they each seat themselves on a cast iron or steel ring, in such a manner that they are practically gas tight when closed. The usual method in the hand filled top rig under description, is for the furnace top crew to wheel the stock from the cage of the hoist and dump the limestone ore or coke on to the top bell. When the pre-determined quantity of stock is dumped, the top bell is lowered and deposits its burden on to the bottom bell. After the requisite number of charges have been deposited on the bottom bell, the top bell is closed tight, and the bottom bell is in turn dumped, thus feeding the charge into the top of the furnace proper. This alternating charging of the top and bottom bell mixes the ore, coke and limestone. The bells are usually operated by means of either steam or hydraulic cylinders. At the outer end of the levers balanced weights are arranged in such a manner that they keep both bells closed.

As will be seen from the description, the method of hand filling necessitated the presence of a crew on the furnace top. This was not only costly labor, but exposed the men to the very serious danger of being "gassed".

The next improvement, and it occurred after quite a number of years was at the foot of the furnace, and consisted in the use of specially designed bottom dump cars for the stock, and elevated trestles over bins for the ore, coke and limestone.

The next step was very radical, and consisted of an inclined skip hoist with a specially designed bucket, which was automatically dumped at the top of its travel. This dispensed with the top filling crew and the greater portion of the bottom wheelers and fillers. Many engineers were contributors to this result, but

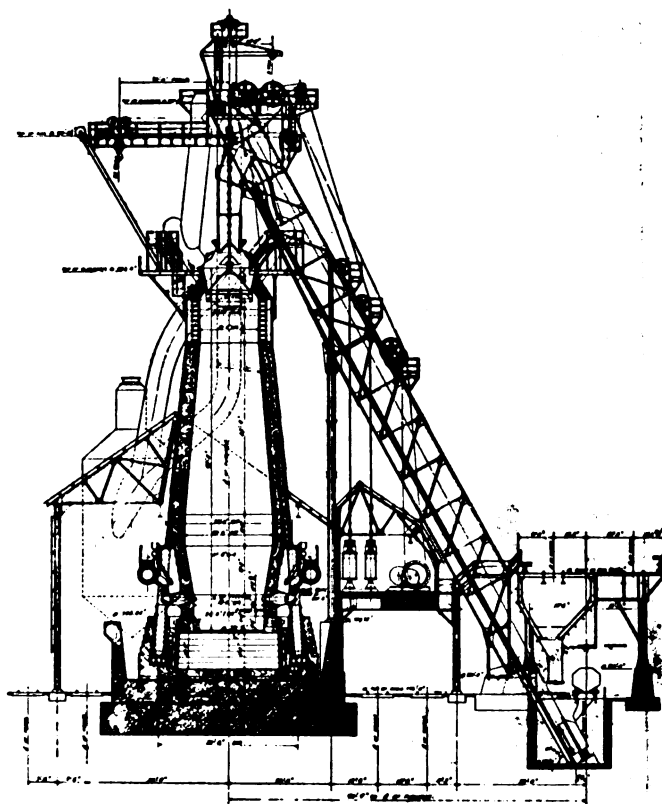


Fig. 1—Cross section of modern blast furnace.

perhaps the greatest individual credit belongs to Mr. Julian Kennedy, of Pittsburgh, Pa.

Fig. 1 shows a typical cross section of a modern blast furnace. This shows wherein lies the vast difference between the obsolete vertical hoist and the inclined skip hoist with its attendant manifold advantages. It will be seen that it is easily possible, not only to clear the furnace columns, but to spot the ladle and ladle car and if necessary one or even two standard gauge tracks under the skip incline, and at the same time allow sufficient head room for the highest standard cars or locomotives. The skips may be sunk in a pit, and the ore, limestone or coke cars, located on a suitable trestle can be unloaded by gravity. The hoisting engine and its house can be profitably arranged

to form part of the trestle structure, making the loading of the skips, and the proportioning of the burden of the furnace not only easy of accomplishment but more accurate than in the previous method.

It is wise to arrange the discharge from the bottom dump cars onto an inclined platform, which in turn leads into the chutes directly over the furnace skips. These final chutes should be in the form of bins with their openings directly over and close to the skips. These bins, by means of the requisite arrangement of gates may be made capable of measuring the charges delivered to the skips. The levers controlling these gates can be arranged in the hoisting engine

operations of more than one man being stationed on the furnace top. His duties are to operate the levers controlling the large and small bells alternately.

These advances seemed to be the turning point as they were rapidly followed by the traveling ore bridge, which enabled stock to be economically handled from widely separated parts of the stockyard, and rendered the expensive stock bins to a great extent unnecessary. They also enabled another great invention to come into use in the shape of a car dumper. This machine takes a fully loaded car of stock off the tracks and hoists it up clear of all obstructions then turns it upside down and dumps the

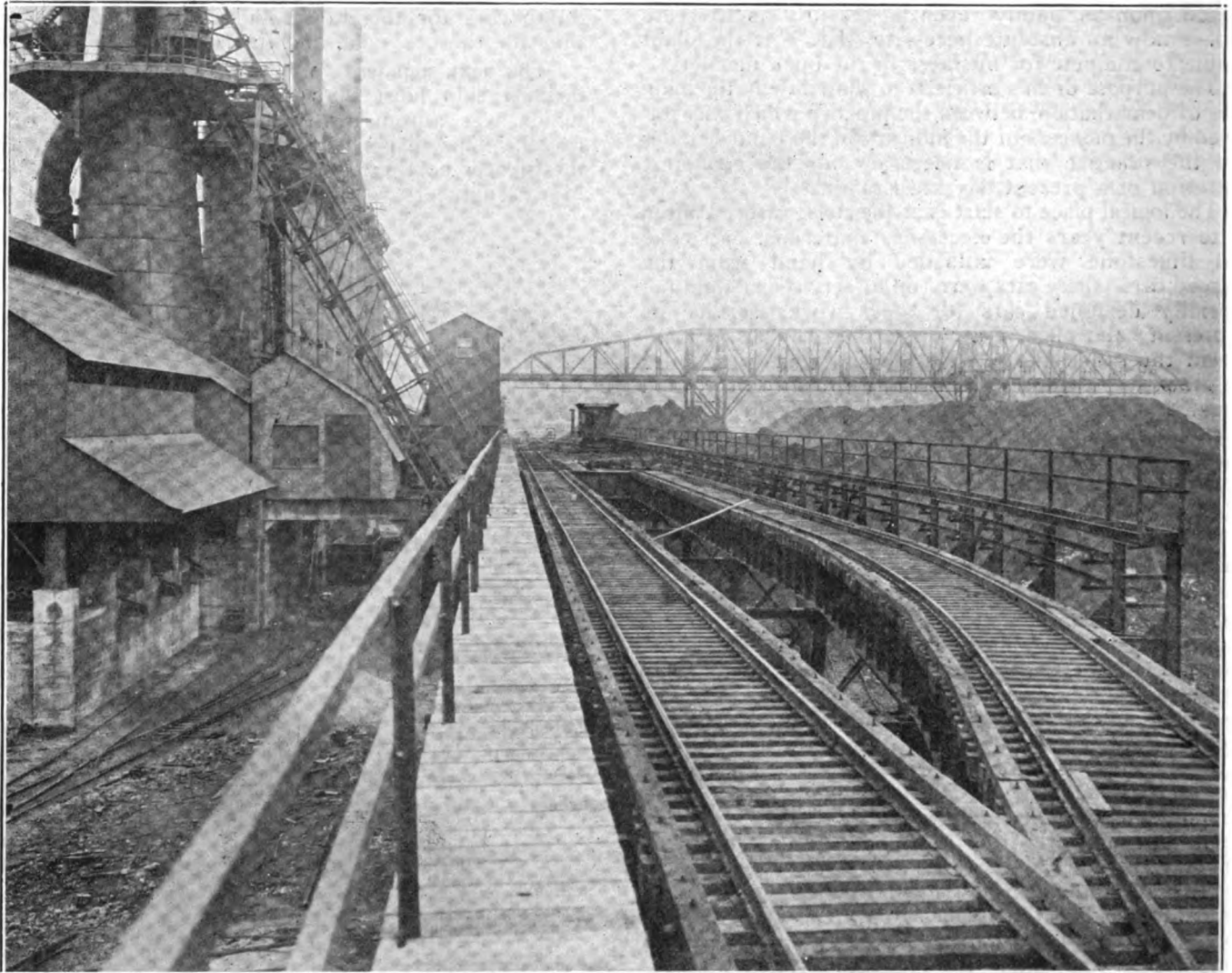


Fig. 2—Ore yard, ore bridge and high line at the Midland Plant of the Pittsburgh Crucible Steel Company.

house, so that the engine man has complete control of the charges and the raising and lowering of the skips to the furnace top. When the skips are at the top of their travel a hook mounted on a sheave engages with a suitable bar on the underside of the device which arrests the upward travel of the front end, the rear end of the skip bucket being still propelled in the upward direction by the hoisting cables turn the bucket to the required angle to discharge the contents, this takes place when the bucket is directly over the small bell already described in the description of the method of filling the furnace.

There is no necessity during the ordinary run of

contents in a pile where they can be reached in turn by the traveling ore bridge and fed to the skip buckets.

One of the main reasons why these improvements at the blast furnace end of the steel plant were so long coming about was the fact that they nearly doubled the capital outlay necessary to construct a furnace of a given size. This fact had the natural tendency to increase the size of the furnaces afterward constructed, as it was found that the same ore bridge and car dumping equipment necessary to serve a 350-ton furnace would suffice for a 500-ton or even larger unit.

Fig. 2 shows a view of a modern ore yard equipped

with an ore bridge and high line. Note how the material is entirely mechanically handled. This view was taken at the Midland plant of the Pittsburgh Crucible Steel Company.

The next step was the moveable car dumper. The author prefers this type to the stationary type. This machine moves on trucks traversing the entire length of the storage yard and dumps the ore over a restraining wall. It is admirably suited for this purpose as it is possible to move the machine opposite the proper portion of the storage yard, thus making the required distribution directly. Any size car can be handled at speeds up to 30 cars an hour. The inclined approach and discharge tracks are attached to the machine and travel with it.

Before leaving the blast furnace end of the industry it may be well to consider other improvements that have been made although they do not enter into the subject matter of this article except incidentally.

In the pioneer days the molten iron was run into sows and pigs in open sand on the cast house floor. This was a very wasteful method and required a veritable army of iron lifters. The resulting product (pig iron) was allowed to become cold and then remelted in the open hearth furnace. A pig casting machine was then designed. This machine consists of a series of cast iron molds mounted on endless chains, and so arranged that the hot metal from the blast furnace is first run into a ladle and from thence poured slowly into the molds, which are kept traveling on their chain belt. The belts are 130 to 140 feet long in two strands and so arranged that they pass over sprockets at both ends, allowing molds to return empty and upside down to the pouring place. The discharge end is arranged over a submerged track and the pigs are discharged by gravity into a waiting car, thus saving all man-handling of the pigs.

Leaving the blast furnace end of a typical plant the next stage is the duplexing plant. This consists of a hot metal mixer and a Bessemer converter. The material is all mechanically handled from the blast furnace to this plant. The hot metal is tapped out of the iron notch of the furnace into a ladle similar to that shown in Fig. 3, which is in turn mounted on a ladle car also shown in the figure. This car is of standard gauge, and is propelled from the blast furnace to the duplexing plant by means of either electricity or steam, usually steam. As will be seen by looking at Fig. 4, the ladle is provided with trunnions, which rest in lugs on the ladle car, when the locomotive has placed the ladle with its car under the crane, the hooks of the crane engage in the ladle trunnions and the hot metal is poured into the mixer. The function of the mixers are to mix the predetermined, and different chemical analyses of molten irons, sufficient of the different constituents being added in the ladle at this stage. As will be seen the mixer is revolvable, and after the mixing action has progressed sufficiently the mixer is tilted backward and an amount is poured into another and smaller ladle which with its car is mounted on the converter platform. This ladle of mixed iron is moved in front of the converter vessel, which is tilted to receive the mixed charge. The ladle is tilted by means of a jib crane and the charge poured into the converter which is the tilted into the upright or blowing position, the blast is then turned on. This is kept on for the requisite time, usually 15 to 20

minutes, and the converter is then moved over the full arc of its travel and discharges the metal into a third ladle. This ladle and car is on ground level, and from this point it is conveyed by another works locomotive to the open hearth furnaces. The function of the Bessemer converter is to blow all the carbon out of the mixture. At the open hearth sufficient carbon, silicon, manganese, and other ingredients are added to make the resultant mixture of the desired chemical analysis.

As described the bulk of the metal is charged hot from the duplex plant into the open hearth, but a small

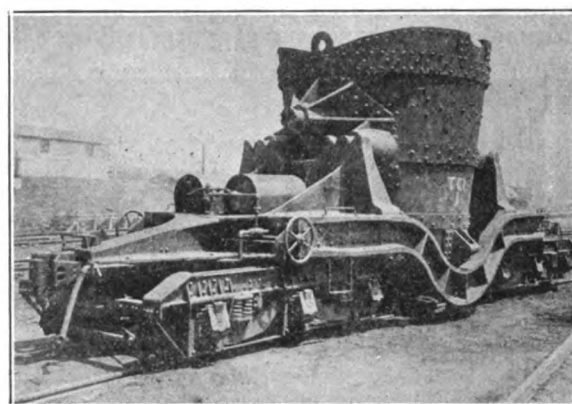


Fig. 3—75-ton hot metal car, Penna. Engineering Works.



Fig. 4—65-ton metal transfer car, Penna. Engineering Works.

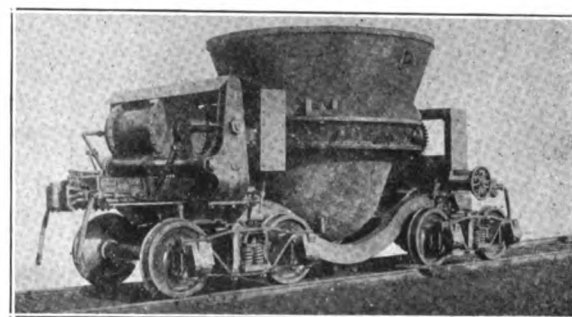


Fig. 5—320 cu. ft. cinder car, Penna. Engineering Works.

amount of cold scrap is always used. This cold scrap is handled by means of a charging machine, which machines are of two main types viz. the low type machine and the high type. There is little to choose between the two types and considerations of headroom, etc., are usually the deciding factors in making the choice.

In charging cold scrap a long plunger called a peal is used. This has its end shaped to engage in the V shaped slot which is cast on the end of the charging box. These charging boxes used to be almost exclusively made of steel plate, but the preference today is for cast steel boxes.

They are doubtless far superior in rigidity and heat endurance which means a longer life, the width and height are 1.10½ inches and 1.6 inches, respectively, while the usual lengths are 6, 7 and 8 feet. Boxes of 4 and 5 feet length are often used on smaller furnaces. These boxes are oblong in shape with the bottom curved to a fair size radius, and are pushed into the furnace by means of the charging machine, which propels the peal over the molten steel on the hearth. When the peal is at full outward stroke the box is turned upside down and discharges its scrap contents on to the hearth. The peal is then revolved another half revolution and withdrawn and the operation is repeated. This work used to be accomplished by hand, and of course nothing like the

shown in Fig. 6 is suspended on the hooks of the ladle crane. The weight of the steel thus tapped is predetermined, and sufficient ingot molds mounted on stools, which are in turn mounted on ingot mold cars, are prepared to receive the melt. These ingot molds, and the ingot mold cars are shown in Fig. 7. These ingot mold cars have M. C. B. couplings and fittings and are run on standard gauge tracks. A second steam locomotive is attached to a train of these cars, usually three to four cars each having four ingots of about 7 tons weight as a load. The locomotive places this crane where it can be reached by the stripper crane and then returns either to take a ladle of hot metal from the duplexing plant to the open hearth

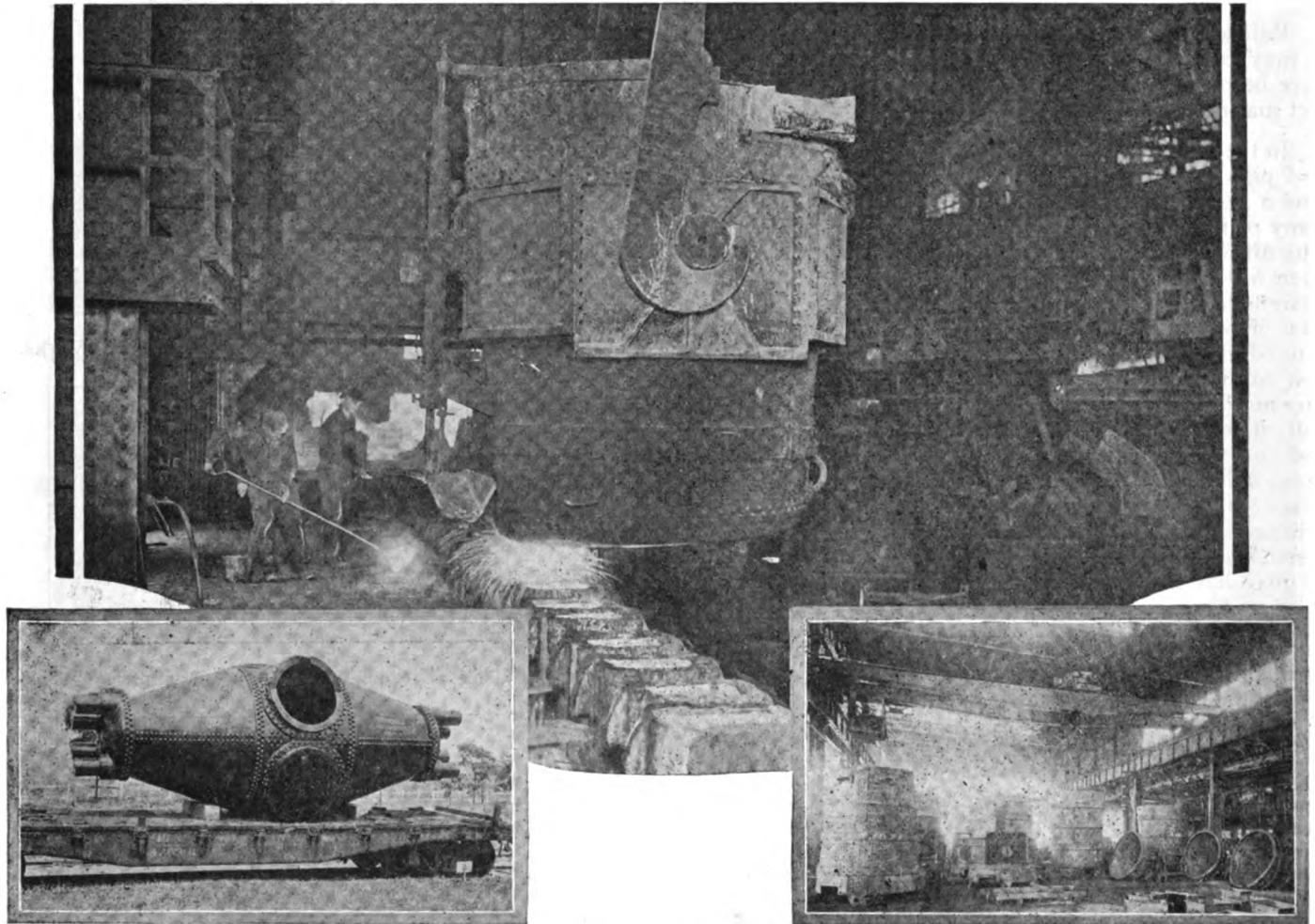


Fig. 6—Pouring a heat with equipment built by the Treadwell Construction Company.

tonnage now obtained was possible, nor was the uniformity of product now obtained possible.

Of a total charge of 2060 pounds of metal in an average (50 ton) furnace a fair proportion would be 1120 pounds of hot metal and 95 pounds of cold pig iron, the balance being made up of bloom crops, plate scrap, ingot butts, rail scrap, turnings, and other light scrap. These latter ingredients must not exceed 140 pounds in the quantity given above because on account of their light weight in comparison with their exposed surface they would oxidize and burn up instead of becoming molten. Records of 3 hours and 40 minutes to melt a total charge of 32,000 pounds of steel from cold metal are not uncommon.

When the heat is ready to pour a ladle such as is

or to bring another train of ingot cars to the stripper crane.

The stripper crane is then reached. This is a specially designed overhead electrical traveling crane, having hooks to engage in the hooks of the ingot mold and a plunger which is operated downward at the same time as the hooks are lifting, the plunger enters the hole through which the hot metal was poured into the mold and forces the ingot downward while at the same time the crane by means of its hooks is stripping the mold from the ingot. Of course a certain amount of time has to elapse between pouring and stripping to allow the ingots to cool and solidify to permit this operation. The stripped ingots are allowed to remain on their stools and their cars and are moved by the locomotive under the soaking pit crane,

This crane is also an overhead electric traveling crane and is equipped with hooks resembling exaggerated ice tongs. These tongs engage the top of the stripped ingot and place them in the soaking pit.

The function of the blooming mill is to reduce the ingots to blooms. The ingots usually have a cross section of 22 by 22 inches at the small end and 27 by 27 inches at the larger end, this taper being necessary to allow for stripping the ingot molds. They vary from 5' 6" to 6' 6" in ordinary cases, and they are reduced on the blooming mill to blooms 8 by 8" in section. At this size the blooms are sheared into workable lengths and are passed on to the billet, bar or shape mill.

A typical blooming mill manipulator is shown in Fig. 8. This manipulator was built by the McIntosh-Hemphill Company of Pittsburgh, Pa., for the Mark Manufacturing Company of Chicago, Ill.

This manipulator is so designed that it has no racks or mechanism of any kind underneath the tables, everything being so laid out that it comes outside of the tables at all times. The tilting feature is new, inasmuch as the whole moving side guard, on the tilting side is raised up and has hanging on it several tilting fingers which catch the piece and turn it over. This is accomplished by means of a tilting cylinder placed alongside the table beams. The manipulator is self-contained and has no connection with the table whatever except on the pusher side where the ends of the pusher rods are carried on the table beam.

A shear approach table is usually of standard design, motor driven and adapted to fit into a 10x10 vertical geared bloom shear. The shear delivery table is so designed that the tilting and stationary sections may be moved away from the shear to allow the crop ends and small slabs to drop into a chute and then into the scrap box. This arrangement is necessary to avoid the delay which would be caused if this unavoidable by-product had to be man-handled.

After the final pass through the blooming mill the bloom or billet is conveyed to the bloom shear. The function of the bloom shear is to cut the hot bloom into such pre-determined lengths as are necessary for the particular order being dealt with. The necessity of this becomes apparent when it is remembered that an ingot which has a section of 22 x 22 inches at the small end and 27 x 27 inches at the large end and a length of 5 feet 6 inches will roll out to an 8 x 8 inch bloom over 60 feet long.

The system of handling the hot ingots, blooms, slabs, bars, shapes or plates has been standardized and in nearly all cases, this being accomplished by means of rolling mill tables. These consist essentially of side frames which support the bearings of the live rollers. These rollers are of varying diameters to suit the work but are usually of the same diameter for the same table to save repetition of patterns.

Fig. 9 shows a typical plate mill, the length of which is so great that the mill proper appears away in the background. This mill is a United Engineering & Foundry Co.'s installation and the illustration was chosen because it shows clearly the tables in operation, and serves to illustrate the method of mechanically handling all rolled material, as the same principle is employed whether the product is bars, shapes or other semi-finished products of the ingots. This mill is of the 3 high or Lauth type and has two rolls, the top and bottom, about 32 inches in diameter and the center one much smaller. The large rolls are stiff

enough to preserve their alignment, the loss of which would mean plates thicker in the center than on the edges. The smaller center roll is supported while at work by one or the other top or bottom rolls and does not need to be so large.

This illustration also shows very clearly the arrangement of the castor beds later described. Until comparatively recent years all sides of the plates were squared by means of cross-cut shears, rotary side trimming shears being only used for wide skelp and universal mill plates. In order to make the rotary side trimming shears a valuable adjunct to a modern plate mill layout recent improvements have been made. One shear housing is stationary, while the other housing is arranged to travel along the bed plate, so that plates of varying widths can readily be sheared. The movable housing is propelled by a motor through gearing and a lead screw and an indicator is provided so that changes in width of plate can be made so quickly that each successive plate can be sheared to a differ-

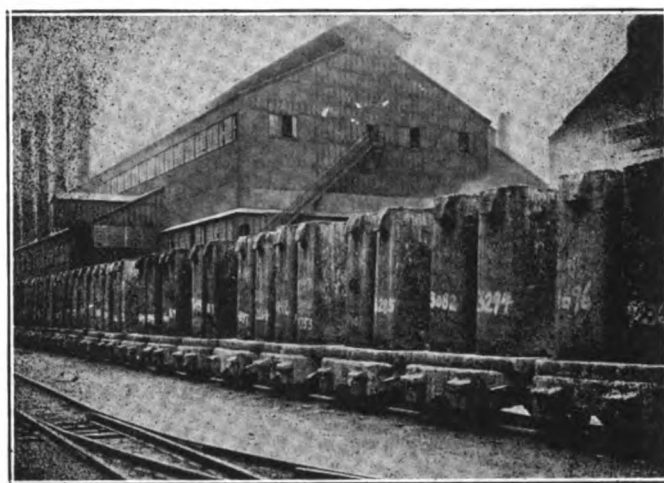


Fig. 7—Ingot moulds and ingot mould cars. These cars are equipped with Hyatt Roller Bearings.

ent width. The adjustment of the top knife was at first accomplished by means of a hand wheel, this is now performed by a motor, and all adjustments are quickly and easily made. These rotary shears are made in two sizes, one having a capacity of ½-inch cold plate, and the other 1-inch cold plate. Either size can be made to take care of any width from 30 inches up.

For trimming wide skelp and all rectangular plates these shears are without a question, the best equipment yet produced, and labor costs will soon make them an absolute necessity in a mill.

The tables in all modern mills are driven by electric motors, which are preferably variable speed, reversing type. The rollers are cast steel cylinders of the requisite length, and are supported in bearings at both ends. The bearings must be very amply proportioned as the service is very severe, and there is a tendency in up-to-date mills to use roller bearings.

Considerations of space, particularly in the lengthwise dimension of the mill site render it necessary to resort to transfer tables to pass the product from one mill to another.

In rail mills these transfers are usually constructed of chains. The rails being run out onto the hot bed after the final pass. These transfers are electrically

driven and are used to take the rails to the hot saws, straightening presses, drill presses, etc.

In many of the other mills which are in common use in the steel industry, it is necessary to transfer the product from one mill to another before the rolling operation is concluded. For this purpose many different types of transfers are made use of, all having the same main object, the reduction of manual labor. One very efficient transfer is a standard, electrically driven rolling mill table, this is mounted with its motors on rails running at right angles to the mills and is propelled from one mill to the other. The tables are reversing, and by means of a duplicate table on the other side of the second mill the piece is returned through the second reduction pass, this is repeated as many times as are necessary and the piece after its last pass on that particular mill is again pointed

be fully adequate to handle the finished product, and wastes outward, besides being amply prepared for the necessary shifting of materials, supplies and product in the process of manufacture.

This equipment consists of steam and electric locomotives, locomotive cranes, weigh bridges, works rolling stock as apart from Railway Company's cars, and last, but not by any means least, the track system.

In many of the earlier steel works the system of trackage received all too scant attention. In the author's opinion this is one of the most vital single parts of steel works design. This will be apparent when the fact is taken into consideration, that even where the trackage and transportation facilities (that is within the works) have been given the most careful consideration and study, every 5 tons of finished product that is shipped necessitates the moving of either a

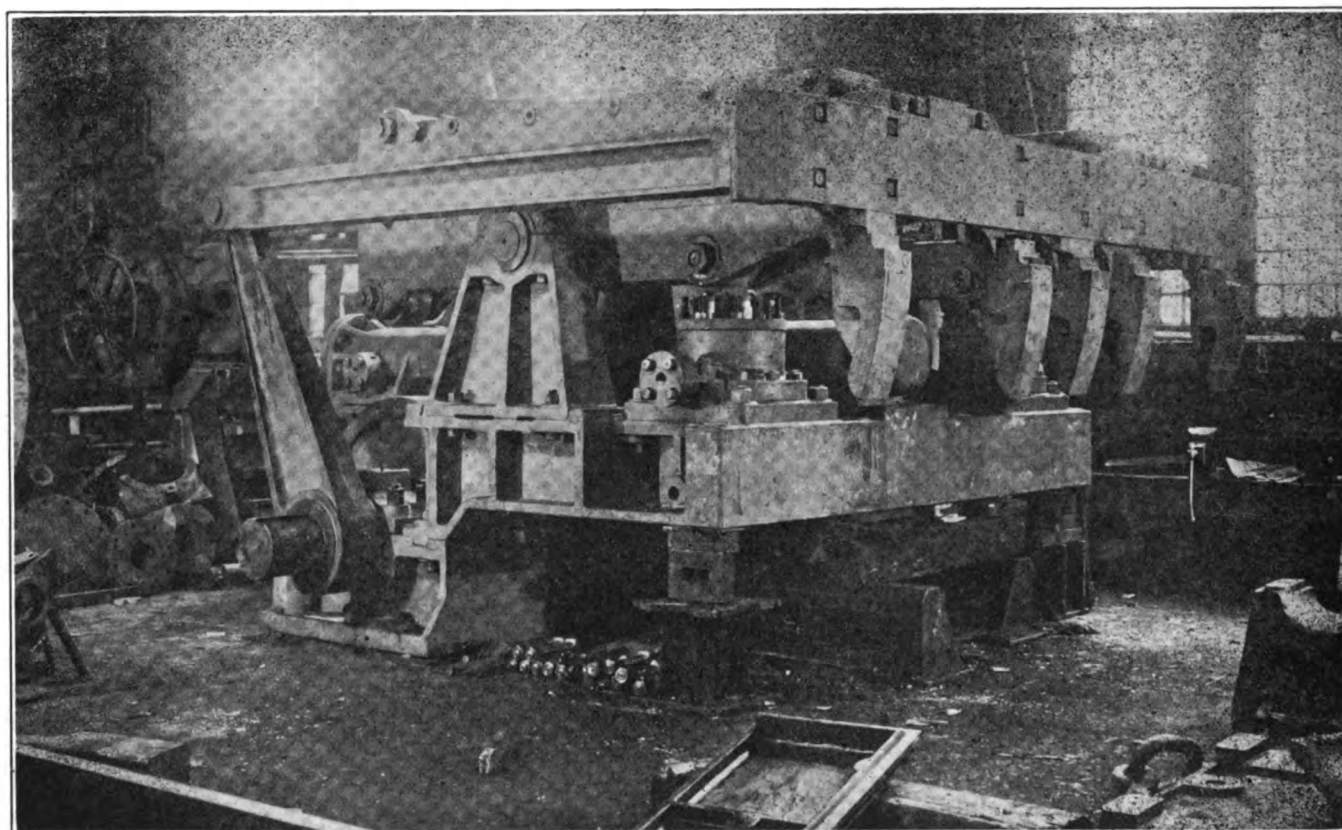


Fig. 8—Showing tilting side of McIntosh-Hemphill Company Manipulator.

in the right direction viz, from the blast furnace and open hearth toward the shipping point.

In plate mills a very ingenious method of transfer is employed in the form of castor beds. These consist of heavy cast iron circular bases having a vertical shaft on which is mounted the "castor" this being exactly the same in construction as the familiar furniture castor. These castors are movable and the bases are made heavy enough that they will "stay put."

Yard Equipment.

This is a very important part of the successful mechanical handling of materials in any plant.

This equipment must be fully adequate to handle all materials, ore, coke, limestone, refractories, fluxes, oils and other supplies, fuels, other than coke and the miscellaneous other materials inward, but must also

full or empty car to a certain distance.

At all points where materials arrive, ladders should be provided, the car space on these ladders of course depending on the extent of the material to be handled, but there should be not less than four lines of parallel tracks. Track curves should be as sharp as possible, as long as the danger of derailment is avoided. For standard gage tracks a curve of 339' .0" radius, and for 3' .0" gage a radius of 50' .0" are practicable and have been found satisfactory. In extreme cases much shorter radii have been used, but are not to be recommended if it is in any way possible to avoid them. For the curve (339' .0") on standard gage track a No. 6 standard frog will be required. As far as possible all frogs and switch points should be of the same number, length and planning. Alteration of the curve radius should be made beyond the heel of the

frog. Ground throw switches should be used, as they are less liable to be the cause of injury to men walking on the tracks particularly at night.

Locomotives.

In the usual layout of a modern steel plant the steam locomotive has been found preferable, this mainly on account of the absence of overhead electric cables. On the other hand, for by-product coke ovens, which are very often run in conjunction with a steel plant, the electric locomotive is perhaps to be preferred.

Fig. 10 shows a typical steel works, steam, locomotive. This was built by the H. K. Porter Company of Pittsburgh, Pa. The outstanding feature of this, as must be the case in all steam locomotives intended for steel works service, is its ability to run with safety around

taking hot metal from the duplex plant to the open hearth charging side and afterwards moving the ingot cars under the soaking pit crane. The third locomotive should be to handle the finished product up to the point of delivery to the railroad company. This will naturally include all car shifts incidental to this service and also the shipment of the wastes.

Locomotive cranes are admirably adapted for handling ore in buckets and other materials at the stockyard, and for transporting skulls, ladle bottoms by means of magnets, from the place of origin to the skull cracker, and transporting the broken skulls, etc. from the skull cracker to the place of disposal and other like service. They can also be used to advantage for spotting cars where necessary in the stockyard or elsewhere throughout the plant, leaving the steam locomotives free for the regular routine

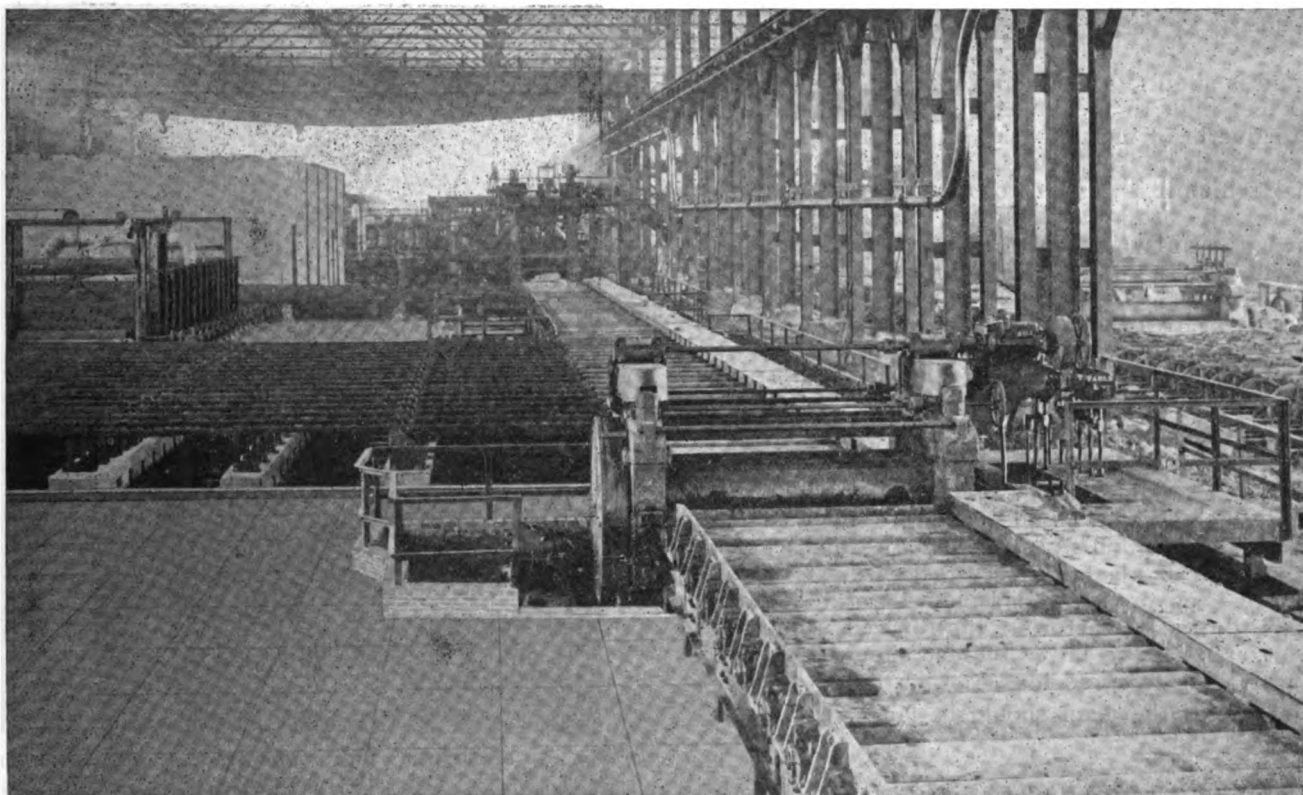


Fig. 9—A plate mill built by the United Engineering & Foundry Co., equipped with every modern improvement, Brier Hill Steel Company.

curves of the minimum radius, and its comparatively heavy drawbar pull.

In a modern steel plant all the yard equipment should be under the direct charge of one official, a good title for whom is Superintendent of Labor. His duties should cover the handling of all materials of every nature in the plant.

From the above it will be seen that the duties of this official play a very prominent part in the elimination of manual labor, and he must make an intensive study of the mechanical handling of all material that comes under his charge. The most economical division of the car shifting operations is to use three steam locomotives for the three main divisions of the work. The first taking hot metal from the blast furnace to the duplex plant or to the open hearth. The second

services as already outlined, and without which it is impossible to operate continuously.

Fig. 12 shows a typical locomotive crane made by the Industrial Works of Bay City, Mich. All locomotive cranes function in exactly the same manner, so that considerations of price, delivery and freight charges are usually the factors determining the choice of makers.

In plants where there is no skull cracker building, or in those plants where there is such a building provided, the locomotive crane is often used as a skull cracker. This is easily accomplished by substituting a standard 36-inch magnet for the usual bucket. The jib of the crane has sufficient elevation to allow the ball to fall through sufficient height to crack the ordinary skull. This is a very convenient feature of an equipment of one or more locomotive cranes, as it is not always convenient to transport skulls, etc.

to the skull cracker, and in many cases the skulls or ladle bottoms can be handled at a point much nearer their place of occurrence, thus saving travel of both the skull and the broken pieces.

A skull cracker building should be an integral part of a well laid out and equipped steel plant. This building is usually located on space which has little



Fig. 10—H. K. Porter locomotive for steel plant use.

value and is about 50 feet span by about 150 feet long and 60 feet high to the lower chord. It is equipped with an overhead electric traveling crane usually of 10 tons capacity. The skulls, ladle bottoms or other material, which it is desired to break up into charging box sizes, are brought under the crane (tracks are provided for this purpose) usually by locomotive crane. The overhead crane is equipped with a magnet usually 36 inches in diameter, this magnet being allowed to engage with a ball of about 5 tons weight. As a rule the ball is lifted to the topmost travel of the crane hook and the current shut off the magnet, the ball falls and the scrap, skull or other material is broken up, this operation is repeated until the material is reduced to charging box size.

All the materials used in the open hearth portion of a modern steel plant should pass through a suitable stockyard. It is good practice to have this separate from the main or blast furnace stockyard. It is thus possible to keep properly classified all of the charge materials, fluxes, refractories, high-priced alloys and recarburizers. These latter in fact should be stored in separate bins to avoid loss.

This part of the plant should be laid out with spe-



Fig. 11—Cutler Hammer magnet.

cial care as to handling facilities, so that manual labor shall be eliminated to the minimum. Ample track facilities should be provided for locomotive cranes, and the entire space should be covered by an overhead electric crane. The tracks should be laid out to economize space, as the ground is much more valuable for storage piles than for empty, or only

occasionally used trackage. Frequent cross-overs must be provided between parallel tracks so located that cars standing for unloading at one bin may be conveniently by-passed for placing at another bin without disturbing the first car.

For overhead traveling cranes a capacity of 10 tons will be sufficient. If but one crane is used it should be rigged to substitute a charging box sling for the usual magnet without undue loss of time. Locomotive cranes operating lifting magnets have a small engine and generator located in the forward part of the turn-table near to the bearings of the boom.

Ladles.

Ladles play a very important part in the handling of the materials in a steel plant. They are of many sizes, from 4 or 5-pound capacity, used in the chemi-

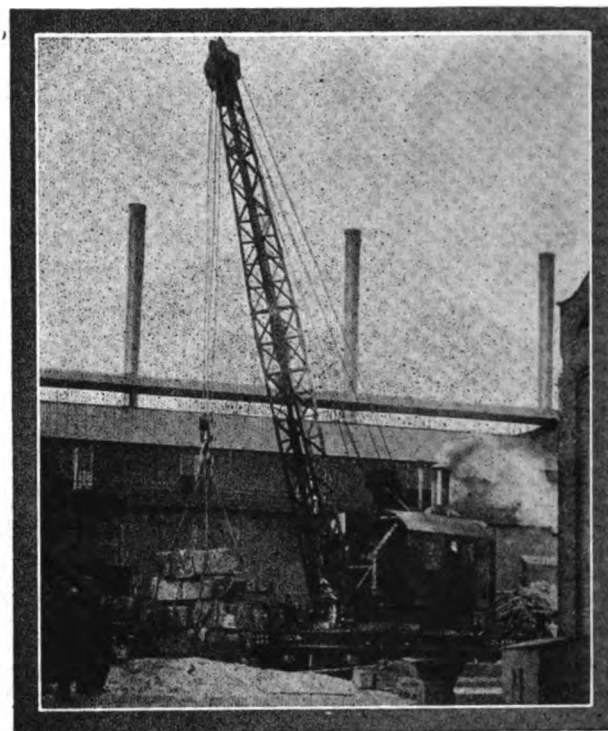


Fig. 12—"Industrial" locomotive crane at plant of Inland Steel Company.

cal laboratory to the 100-ton ladle used in conjunction with the ladle crane. Fig. 5 shows the pouring side of the open hearth cinder ladles, which are used for transporting cinder from the blast furnace to the place of disposal. These ladles are mounted on ladle cars, equipped with standard M. C. B. couplers and arranged to operate on standard gage tracks. As a general rule cinder ladles are not demountable, being seldom used apart from their cars, in which respect they differ from the hot metal ladles which are provided with trunnion, so that they may be dismounted from the cars and swung by means of their trunnions from the hooks of the various cranes. These trunnions serve a double purpose as they form pivots around which the ladles may be turned for the purpose of pouring out their contents. All ladles that may at any time be used for hot material must have a substantial lining of very refractory firebrick. Ladle lining repairs constitute a very heavy item of expense, so the greatest care is taken with the design and handling of all ladles and ladle cars.

Heat Transfer in Open Hearth Furnaces

Some Considerations Regarding the Manner in Which Heat Is Transferred From the Flame to the Bath in an Open Hearth Furnace.

By HENRY WILLIAM SELDON,
See—Seldon and Associates, Engineers, Pittsburg, Pa.

MECHANICAL Engineers' Pocket Book, Wm. Kent 1916, describes the three methods of heat transfer as follows:

Conduction, is the transfer of heat between two bodies or parts of a body which touch each other. Internal conduction takes place between the parts of one continuous body and external conduction through the surface of contact of a pair of distinct bodies.

The rate at which conduction, whether internal or external, goes on, being proportioned to the area of the section or surface through which it takes place, may be expressed in thermal units per square foot of area per hour.

Convection, or carrying of heat, means the transfer and diffusion of the heat in a fluid mass by means of the motion of the particles of that mass. Ex. (by air currents)

Radiation of heat takes place between bodies at all distances apart and follows the laws for the radiation of light. The heat rays proceed in straight lines and the intensity of the rays radiated from any one source varies inversely as the square of their distance from the source. The quantity of heat radiated by a body is also a measure of its heat absorbing power under the same circumstances. When a polished body is struck by a ray of light it absorbs part of the heat and reflects the rest. The reflecting power of a body is therefore the complement of its absorbing power, which latter is the same as its radiating power.

Flame may be defined as a mass of intensely heated gas in a state of combustion, although it is possible for flame to exist as a gas not actually in such a state.

The luminosity of flame, or the characteristic which gives its visibility, is due to the heating to incandescence of the unconsumed particles of combustible matter present in the gas. The variation in the colors of flame is due to the difference in the degree of heat communicated to these particles. The higher the temperature of these particles the whiter the flame. The length and volume of the flame will vary with the combustible elements present and the thoroughness with which the air and combustible elements are mingled and since such number will decrease with an increase in the completeness of combustion, the shorter the flame, in the absence of any outside cooling medium, the more rapid and complete the combustion. If it were possible for the combustion of any fuel to be complete and instantaneous there would be no visible flame, since both carbon dioxide and water vapor are invisible.

Visible flame, then is evidence of incomplete or non-combustion, but such evidence in the commercial furnace means simply that the combustion has not taken place with sufficient rapidity to evolve heat instantaneously.

It follows from the above that for a given amount of fuel burned, a short flame will ordinarily mean rapid and complete combustion, a longer flame delayed combustion and a very long flame imperfect or non-combustion.

It is well to distinguish between perfect and complete combustion.

Perfect combustion is the result of supplying the requisite amount of oxygen for union with all of the oxidizable constituents of the fuel and utilizing in combustion all the oxygen so supplied.

Complete combustion on the other hand results from the oxidization of all the combustible constituents of the fuel but does not of necessity imply the utilization of all of the oxygen supplied.

The speed of combustion is dependent upon the affinity of the combustible matter for oxygen and the conditions under which combustion takes place. The chief of these conditions is that of temperature. It does not of necessity follow that by bringing oxygen into the presence of a combustible substance that combustion will take place. Every combustible substance has a temperature called its ignition temperature below which it will not burn or in other words unite with oxygen.

Ignition temperatures with which we are concerned are as follows:

Ethylene	C_2H_4 —1022 degrees (F)
Hydrogen	H_2 —1130
Methane	CH_4 —1202
Carbon Monoxide	CO —1210

Excess air passing through the furnace and mingling with the actual products of combustion absorbs heat from such products more readily than will the bath of the furnace, and a considerable portion of the heat so absorbed is carried off in the escaping gases. This accounts for a part at least of the increase of the exist gas temperature with an increase of excess air. Another factor is dependent upon heat transfer rates namely difference in temperature between the gases and the bath, the percentage of total heat absorbed through radiation and the percentage of total absorption through convection.

The following from the Babcock & Wilcox boiler data:

The amount of heat absorbed by any surface from a hot gas is usually expressed as a product of the difference in temperature between the gas and the absorbing surface into a factor which is commonly designated as the "transfer rate."

Recla assumed that the transfer rate was constant and independent both of the temperature differences and the velocity of the gas over the surface.

Rankine on the other hand assumed that the transfer rate, while independent of the velocity of the gas, was proportionate to the temperature difference and expressed the total amount of heat absorbed as pro-

portional to the square of the difference in temperature.

Neither of these assumptions has any warrant in either theory or experiment and are only valuable in so far as their use determines formulae that fit experimental results. Of the two Rankine's assumption seems to lead to formulae that more nearly represent actual conditions.

Prof. Osborn Reynolds, in a short paper reprinted in Vol. I of his "Scientific Papers," suggests that the transfer rate is proportional to the product of the density and velocity of the gas and it is to be assumed that he had in mind the mean velocity, density and temperature over the section of the channel through which the gas was assumed to flow. Contrary to prevalent opinion, Prof. Reynolds gave neither a valid experimental nor a theoretical explanation of his formula.

The above deductions are all based on conductivity and heat transfer in boilers.

Conductivity of air.....	.0122 (1 + .00132T)
Conductivity of carbonic gas.....	.0076 (1 + .00229T)
Conductivity of superheated steam...	.0119 (1 + .00261T)

T—is temperature in degrees Fahrenheit.

No account in any of the above has been taken of radiation of heat from the gas. Since the common gases absorb very little radiant heat at ordinary temperatures, it has been assumed that they radiate very little at any temperature. This may or may not be true for boilers, but certainly a visible flame must radiate as well as absorb heat. However, this radiation may occur, since it would be a volume phenomena rather than a surface phenomena, it would be considered somewhat differently from ordinary radiation. It might apply as increasing the conductivity of the gas which however, independent of radiation, is known to increase with the temperature. It is, therefore, to be expected that at high temperatures the rate of transfer will be greater than at low temperatures. The experimental determinations of transfer rates at high temperatures are lacking.

Although comparatively nothing is known concerning the heat radiation from gases at high temperatures, there is no question but that a large proportion of the heat absorbed by a boiler is received direct as radiation from the furnace. E. Houbauer (Seraing, Belgium) calls attention as follows to the too marked tendency in the combustion gases to form an erroneous estimate of their value:

The conception of the "calorific power" of gases has no importance from the point of view of their value in use: it is, obviously, the sole absolute factor of these fuels, calculable either theoretically, having regard to their chemical composition, or practically, by calorimetric methods. But their true value depends solely on the temperature of combustion, a factor impossible to determine definitely, in as much as it depends essentially upon the conditions under which that combustion occurs, and it is precisely those variable conditions which it is necessary to determine in order to obtain the greatest possible yield from the fuel employed.

With the object of affording concrete examples and of being able to base his arguments on such figures the author has ascertained them (by M. Le Chatelier's method) and under the variable conditions which may be met within practice, for three types of

(1) blast furnace, (2) gas producer and (3) coke-oven gases, the chemical compositions of which are given below. The figures in the analysis show the average composition of the gases available at the Cockerill Works. The factors have been calculated in each instance, not on the assumption that the gases undergo neutral combustion, but with the admission of 25 per cent of air in excess.

Composition of the Gases.

Constituents	Coke Oven Gas	Producer Gas	Blast Fur- nace Gas
Hydrogen	57.00	12.00	3.00
Carbon Monoxide	6.00	19.00	26.00
Carbon Dioxide	2.00	8.00	11.00
Methane	23.00	2.00	...
Nitrogen	12.00	59.00	60.00

Coke Oven Gas.

Minimum calorific power.....	3761 calories
Minim. calorific power with condensed steam	4212 calories
Temperature of combustion (gas unheated (air heated to 600 degrees)	1940 degrees
Temperature of combustion (gas unheated (air heated to 1000 degrees)	2165 degrees
Temperature of combustion (gas unheated (air heated to 400 degrees)	1825 degrees
Temperature of combustion (gas unheated (air unheated)	1600 degrees
Volume of air of combustion corresponding to one volume of gas (including) 25% excess	4.88 volumes
Volume of smoke	5.48 volumes

Blast Furnace Gas.

Minimum calorific power	873 calories
Minim. calorific power with condensed steam	891 calories
Temperature of combustion (gas unheated (air heated to 200 degrees)	1325 degrees
Temperature of combustion (gas unheated (air heated to 600 degrees)	1465 degrees
Temperature of combustion (gas unheated (air heated to 800 degrees)	1540 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 600 degrees)	1695 degrees
Temperature of combustion (gas heated to 900 degrees) (air heated to 900 degrees)	1920 degrees
Volume of air of combustion corresponding to one volume of gas (including 25% excess)	0.91 volumes
Volume of smoke (including 25% excess)....	1.76 volumes

Producer Gas.

Minimum calorific power	1068 calories
Minim. calorific power with condensed steam	1135 calories
Temperature of combustion (gas heated to 600 degrees) (air unheated)	1530 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 400 degrees)	1680 degrees
Temperature of combustion (gas heated to 600 degrees) (air heated to 600 degrees)	1760 degrees
Temperature of combustion (gas heated to 900 degrees) (air heated to 900 degrees)	1980 degrees
Volume of air of combustion corresponding to one volume of gas (including 25% excess)	1.22 volumes
Volume of smoke (including 25% excess)....	2.06 volumes

This puts us in possession of the factors necessary

for the comparison of these fuels. In order to throw into relief the valuelessness of the conception of the calorific power, the temperature of combustion of the producer gas with 1,068 calories may be instanced when the gas and air are heated to 900 degrees, that is to say 1,980 degrees as compared with the temperature of combustion of the coke-oven gas, with 3,761 calories, which is only 1,940 degrees when this gas is employed cold and the air of combustion is heated to 600 degrees.

In short, it is obvious that in such a case when high temperatures of working are necessary, it is better to employ a gas capable of giving very high temperatures of combustion.

Mr. Houbaer states in his discussion of the use of coke-oven gases in the open hearth furnace the principal advantages are as follows:

1. Increase in the production.
2. Simplification in construction.
3. Diminution in the repairs, particularly as regards the ports and chambers.
4. Possibility of using a cheaper charge.
5. Ease with which the operation can be conducted.

Examples from the Cockerill Steel Works, show an increase of 34 and 23 per cent respectively in tonnage over using producer gas as a fuel (12-ton furnace). He states further: "The utilization of a gas with a higher temperature of combustion allows of greater economy in the pig iron in the charge; at the above works the average percentage of pig iron has fallen from 31 to 20 per cent by employing coke-oven gases instead of producer gas."

Prof. W. A. Bone (Imperial College of Science and Technology, London) in the discussion of the paper by E. Houbaer on the "Utilization of Blast Furnace and Coke Oven Gases in Metallurgy," before the British Iron & Steel Institute in 1913, said:

The question of the temperature of combustion is one of the most intricate and important which could be raised in connection with the subject of flame.

Of all the factors which might contribute to the determination of flame temperatures, initial temperature of the system, energy developed in combustion, specific heats of burnt gases, the question of the mechanism and duration of the chemical change in combustion and the question of radiation from the flame, must also be considered, as both factors would affect the temperature realized.

The expression "temperature of flame" conveyed to his mind very little meaning when flame in bulk, and not merely local temperature was in question. A mixture of unburnt gas and air might be taken as representing so much potential energy which could be liberated—not necessarily wholly as sensible heat when chemical change occurred and the burnt gases were formed. The energy liberated might be divided into two parts—namely, (1) the energy emitted by direct radiation and (2) the energy immediately communicated to the burnt molecules as kinetic energy (that was as sensible heat) which determined the temperature of the flame.

The modern conception of the process of explosive combustion was that at the moment when a system of molecules entered into chemical change and during the moment of chemical change, if he might use that

expression—a sort of vibratory system was formed. For instance taking the simplest case and supposing hydrogen was being burnt, the hydrogen and oxygen molecules came together by collision and for an instant, which was indefinitely short, but which was very important from the point of view of the ultimate result there was formed not steam but a vibratory system of hydrogen and oxygen. Such a system was in a state of intense vibration and during its transitory existence would omit a considerable amount of radiant energy which would not therefore be manifested as sensible heat in the product. Then came the formation of steam and at the moment of formation the steam was, no doubt, still in vibratory condition. Finally as the result of collisions with the other molecules of steam and also with some of the inert gases, the system settled down to a steady non-vibratory state. The burnt products would now be in a state of very rapid translatory movement and would therefore be at a high temperature. He desired the members to bear in mind that the whole of the energy of the combustion was not imparted immediately to the products as kinetic energy (that was, as sensible heat). Therefore any calculations of flame temperature based simply upon total energy or total heat of combustion and the specific heats of the products would yield too high a result. Thus, for example, if in a given change 10 per cent of the energy was directly radiated off, then only 90 per cent would be immediately communicated to the products as sensible heat which determined temperature.

The subject of the radiation from flames was first studied scientifically by Robert von Helmholtz a good many years ago. Von Helmholtz, working on quite small flames, determined that from a coal-gas flame, 6 millimeters in diameter, 5 per cent of the energy was radiated; from a carbon dioxide flame 8 per cent, and from a hydrogen flame 3 per cent. Those numbers, however, only held good for small flames. There was no doubt that in a large flame more energy than that was radiated out and it was impossible to define absolutely—it could only be done relatively—the amount of energy directly radiated away in any given case. Radiant energy was very important in furnace operations, because in such operations it should be the object to heat as far as possible by radiant energy. The fact that carbon monoxide gave a better radiating flame than hydrogen might partly explain why in a furnace it was better to use a gas in which there was a higher percentage of carbon monoxide than one of equal calorific value in which there was a high percentage of hydrogen.

Some very important experiments were carried out in 1890 in Berlin by Julius, who showed from spectroscopic investigations that the whole of the radiation in flame was due to incipiently formed carbon dioxide and steam molecules and the amount of the radiant energy emitted by a given flame might be regarded as derived additively from the volume of steam and carbon dioxide produced by the combustion of unit volume of the gas. Thus, in a certain series of experiments upon the amount of radiation emitted from a number of different flames, Julius formed a value of 74, which was simply an arbitrary and relative number for a hydrogen flame per liter of gas burnt, for a similar carbon monoxide flame he found a value of 177 per liter, from which it appeared that a carbon monoxide flame emitted nearly two and half times as much radiant energy as a hydrogen

flame of the same dimensions. In the case of a methane flame he similarly obtained a value of 327 per liter; on the supposition that that was the addition derived from the amount of carbon dioxide and steam produced during combustion, that number should have been 177 plus 2 times 74 or 325, which closely agreed with that actually observed. For all other hydrocarbons, or mixture of gases, the same relation was found to hold good.

In forming any estimate of flame temperatures under given conditions, it is evident that the question of radiation must be taken into account. As a further example, it has been proved in experiments upon internal combustion engines that the fact of making the inside of the engine cylinder reflecting, for instance, by silver-plating, it raised by about 5 per cent the maximum pressure of explosion and therefore the power developed from the gas. That was due to the fact that the radiant energy was not absorbed by the walls of the gas engine so quickly as it would have been with blackened walls, but that it was reflected through and through the gases and gradually absorbed by combustion products.

Prof. H. LeChatelier in the journal of the Iron and Steel Institute (1919) for discussion on Fuel Economy Papers wrote as follows:

"The manipulation of steel furnaces with heat recuperation was an exceedingly delicate operation, owing to the very small differences which existed between the fusion points of the refractory materials and that of the steel. The best bricks, which were silica bricks, fused at 1,700 degrees "C" while the temperature of dead soft steel had to be, at the time of pouring 1,600 degrees at least. Its solidification point was about 1,550 degrees "C," and it was at least necessary to have an excess temperature of 50 degrees to be able to pour it into a ladle and from the ladle into the molds before solidification commenced. The mechanism of the heat exchanges between the flame and the heated metal was such, however, that under ordinary conditions in regenerative furnaces the roof (radiation from which served as a medium for that exchange) required to be at a considerably higher temperature than the bath. The combustible gases arriving in the furnace were deprived of all illuminating power and therefore possess a negligible emissivity. On leaving the producer they contained only a very small amount of hydrogen carbides—3 per cent of the methane at most and that compound was destroyed during the passage of the gas to the recuperators, as much by the action of the heat alone as by that of the water vapor and the carbonic acid. Those gases, at the moment of combustion, practically contained only hydrogen and carbon monoxides and burned with a flame giving hardly any luminosity and radiating but very little heat. The greater part of the heat was exchanged by convection, that was to say, by the contact of the gas with the solid heated materials. It was for that reason that the ports were inclined so as to direct the jet of flame on to the bath of steel. Long before, however, the hot gases had yielded up the whole of their available heat, they ascended, owing to their lower density to the upper part of the furnace, that was to say, to the roof, to which in the end they yielded the greater part of their heat. The roof thereupon radiated the heat it had thus received on to the bath of the steel. To do that it had to be appreciably hotter than the bath, the more so as the heat had to be transmitted to the

metal through the layer of slag which covered it. Stefan's law allowed of the quantities of the heat thus radiated being calculated. For a black body the quantity of heat radiated by 1 square centimeter of a body at absolute temperature T from a semi-sphere at temperature T° was given by the formula:

$$Q \text{ equals } 1 \times 36.10 \cdot 12 (T^4 - T^{\circ 4})$$

in which Q was the calorie-grammes per sec.

If the temperature of the roof were assumed to be 1,700 degrees C., and that of the surface of the bath 1,600 degrees C., that was to say a difference of 100 degrees, it would be found that the amount of heat received per square centimeter of the surface of the bath per second was 4 calorie-grammes.

It would be exceedingly important from the point of view of the conservation of the roof and indirectly from the point of view of the fuel consumption, to yield as much heat as possible directly to the bath without the intervention of radiation from the roof. It should then be possible to work the charge without letting the roof become hotter than the bath or if it would be preferred to maintain the actual temperature of the roof, to impart more heat to the bath per unit of time, which would accelerate the operations and proportionally diminish the amount of coal burned.

Two methods appeared worthy of trial.

1. To increase the emissive capacity of the flame by injecting directly into the furnace a small amount of tar so as to occasion a precipitation of solid carbon in the flame. The latter would thereupon directly radiate a portion of its heat on to the bath.

2. To deflect the hot flame already burned at the surface of the bath by means of jets of high pressure compressed air directed from the roof of that half of the furnace situated at the outlet end of the gases. In the first half of the furnace such jets would not be necessary as the flame would be already inclined towards the bath owing to the inclination of the ports, besides which the current produced by such jets would too greatly accelerate combustion and give too short a flame. The higher the pressure of the air thus blown in, the less would be required to deflect the hot gases towards contact with the bath and assist heating by convection. It would be important naturally, not to cool down the flame. Economy of fuel could only result from the employment of the most accurate proportion of air for combustion.

The authors of the paper on Fuel Economy, Professor William A. Bone, Sir Robert Gadfield and Mr. Alfred Hutchinson took exception and did not agree with one of the points in Prof. LeChatelier's communication.

Prof. LeChatelier had rightly drawn attention to the importance of radiation from the flame of the gases burning in open hearth furnaces, but he was wrong in stating that, inasmuch as those gases practically contained only hydrogen and carbon monoxide, they burnt with a flame radiating but little heat. Also, it was questionable whether the emissivity of a flame would be much (if at all) increased by injecting into it a small quantity of tar so as to occasion a precipitation of a solid carbon. As a matter of fact, scientific investigation had proven that the principal source of radiation from flames was incipiently formed CO_2 and H_2O molecules which, at the moment of their birth, were in a highly vibratory condition. A CO flame radiated about 2.4 times as

much energy as did an H_2 flame of the same dimensions; and the emissivity of a Bunsen coal-gas flame was not materially increased by cutting off its primary air supply altogether. The whole subject of radiation from flames had been fully dealt with in the third report (1910) of the committee of the British Association appointed for the investigation of gaseous explosions, a perusal of which would help furnace managers to understand the cause of radiation from flames and its dependence upon (1) the size of a flame (particularly area), (2) its degree of areation, and (3) the chemical composition of the gas burnt.

The following is given from this report:

In the investigation of combustion of gases at high temperatures one factor relating to surface combustion must be considered in connection with the influence of moisture.

Prof. Dixon found 30 years ago that dry carbonic oxide and oxygen were not inflammable.

Dr. Bone had found that carbonic oxide, thoroughly dried, accelerates surface combustion in a very marked degree. If he took a mixture of carbonic oxide and oxygen and saturated it with (say) 1½ per cent of moisture a certain value would be obtained, i. e. a certain amount of gas would disappear in a given time. If this mixture were thoroughly dried, it would be found that the value obtained before was about doubled. In other words, the removal of the trace of moisture had the effect of very greatly accelerating the action of the surface in bringing about the combustion of the carbonic oxide.

Prof. Callendar in a paper before the Royal Society in 1906 found with a Bunsen flame, with air and gas adjusted as nearly as could be estimated in the proportion required for complete combustion, the proportion of heat radiated varied from 10 to 15 per cent for flames from 1 to 4 inches in diameter. As the

air supply was reduced for the same rate of gas consumption the size of the flame increased and also the amount of heat radiated. A maximum of 15 to 20 per cent was reached for these burners when a brilliant well-defined inner cone was formed. If the amount of air supplied was in excess of that required for complete combustion the radiation fell off considerably in consequence of reducing in size and fall in temperature of the flame. Reducing the air supply the temperature was reduced and radiation fell 12 to 16 per cent. With steady luminous flames, there was a considerable increase of radiation on excluding air from the flame. With small flames of low temperature the proportion of heat radiated might be as low as 2 or 3 per cent.

These experiments indicate that radiation depended largely upon the size of the flame as well as on the temperature and on the presence of CO or solid C, when the air was insufficient for complete combustion.

Data representing British practice in the years 1914-5. The identity of each firm is concealed by a distinctive Roman numeral.

The following descriptive terms were used:

"Molten Pig Processes" } Where 85% (or more) of the total metal charged was made up of molten pig iron from the blast furnace.

"Mixed Processes" } Where the proportion of molten pig iron in the charge varied between 40 and 70 per cent, the remainder of metal (pig and scrap) being cold.

"Cold Processes" (when no molten metal at all was charged)

Summary of Results.

	Cwt. coal per ton of ingots	Average cwt.
(a) Molten pig processes.....	6.00 to 7.00	6.35
(b) Mixed processes	6.25 to 8.75	7.65
(c) Cold processes	7.00 to 12.00	9.45

Coal Consumption in British Steel Works "Molten Pig Processes"

Metal Charged Per Ton of Ingots Made.				(Actual consumption at steel works per ton of ingots rolled into finished sections.						(Coal consumption at B. F. and coke ovens per ton of ingots rolled into finished sections.			
Firm No.	Molten pig iron cwt.	Cold pig iron cwt.	Cold scrap cwt.	Types and Sizes of Open Hearth Furnaces	(A) Open hearth furnaces cwt.	(B) Soaking pits or reheating furnaces cwt.	(C) Rolling Mill cwt.	(D) Other furnaces	Total cwt.	At coke ovens cwt.	For calcining and other purposes cwt.	Total cwt.	Grand total cwt. of coal consumer per ton of ingots from ore to finished steel sections.
VI	16.16	1.63	0.13	Basic 7 x 55 tons 2 x 65 tons	6.36	1.46	2.44	1.79	12.05	28.70	2.65	31.35	43.40
VII	17.5	Nil.	1.73	Basic 1 x 250 tons Talbot 2 x 60 tons Wellman	6.09	Nil B. F. and C. O. gases used	4.76	10.85	27.77	3.03	30.80	41.65	
VIII	17.5	Nil.	2.00	Basic Talbots 100-175 tons	6.00	3.50	3.50	2.00	15.00	40.00	Nil.	40.00	55.00
IX	17.0	Nil.	3.25	Basic 4 x 45 tons Producing High-Grade Alloy Steels	7.00	3.0	Nil. B. F. Gas Used	1.65	11.65	38.25	Nil.	38.25	49.90

Coal Consumption in Steel Works Using "Mixed Processes"

—Metal Charged Per Ton— of Ingots					—Actual Coal Consumptions at Steel Works— per ton of ingots rolled into finished sections.					Coal required at coke ovens and blast fur- naces to produce the pig iron used cwt.	Grand Total of Coal Consumed Cwt.
Firm No.	Molten Pig Cwt.	Cold Pig Cwt.	Cold Scrap Cwt.	Types and Sizes of Open Hearth Furnaces	(A) Open Hearth Furnaces and Mixed Cwt.	(B) Soaking Pits and Re- heating Furnaces Cwt.	(C) Rolling Mills Cwt.	(D) Other Purposes	Total Cwt.		
XII	8 to 10	2.0	10 to 8	Basic 6 x 45 tons 2 x 60 tons	6.25	3.05	1.5 Partly Driven by Gas	Nil.	10.80	21.0	31.80
XIV	14 to 15	Nil.	6.0 to 6.5	Basic 2 x 25 tons 1 x 40 tons 1 x 50 tons 2 x 60 tons	8.75	5.1	5.50	Nil.	19.35	25.70	45.05
XVI	12.4	0.8	6.7	Basic ?	8.00	2.75	2.50	0.60	13.85	22.40	36.25

Coal Consumption in Steel Works Using "Cold Processes"

Firm No.	XV	XXII	XXIII		
Metal charged per ton of ingots.	11.5	12.0	9.4 to 11.0		
	12.5	9.0	11.0		
Types and sizes of open hearth furnaces used	Basic	Acid	Acid	Basic	
	14 tons	2 x 30 tons 2 x 22 tons	1 x 50 tons 3 x 40 tons	5 x 50 tons	
Actual coal consumption at Steel Works. Cwts. per ton of ingots rolled into finished sections.	Cwt.	Cwt.	Cwt.	Cwt.	
	(a) Open hearth furnace and mixers	9.75	12.00	7.00	9.00
	(b) Reheating furnaces, etc.	2.00	4.50	8.25	8.25
	(c) Rolling mill	3.75	4.00	3.75	3.75
	(d) Other purposes	3.00	1.25	1.25	2.00
Total Cwts.	18.50	21.75	20.25	23.00	

Firm No.	From	CO ₂	CO	O ₂	N ₂	Average Temperature C°
VI.	Open hearth furnaces	9.2 to 14.3	Nil	4.5 to 8.0	80.8	550°
	Soaking Pits	7.5	Nil	10.6	82.9	350 to 600°
	Gas Fired	17.9	Nil	4.9	71.2	600
	Coal Fired	11.6	Nil	7.4	81.0	237
IX.	Open Hearth Furnaces	10.15	Nil	6.0	83.85	400°
	Boilers	12.95	Nil	5.15	81.90	250°

Firm No.	Gases From	CO ₂	CO	O ₂	N ₂	Temperature C°
XII.	Open Hearth Furnaces	9.5	Nil	8.8	81.7	480 to 870°
	Coal Fired Boilers	12.0	Nil	7.25	80.75	300 to 350
XIV.	Open Hearth Furnaces	8.0	Nil	9.5	82.5	525°
	Soaking Pits	4.0	Nil	15.0	81.0	480
	Reheating Furnaces	5.6	Nil	13.0	81.4	320
	Boilers	5.9	Nil	10.8	83.3	350
XVI.	Open Hearth Furnaces	12.30	Nil	8.65	79.05	620°
	Reheating Furnaces	13.60	Nil	8.65	79.05	200
	Boilers	12.0	Nil	8.65	79.05	210
		10.2	Nil	8.65	79.05	260

Firm No.	Waste Gases From	CO ₂	CO	O ₂	N ₂	Temperature C°
XV.	Open Hearth Furnaces	9.8	...	8.8	81.4	655°
	Reheating Furnaces	13.4	...	4.2	82.4	590
XXII.	Reheating Furnaces	12.0	Nil	4.2	83.8	565 to 785
	Boilers	6.8	Nil	11.0	82.2	385
XXIII.	Open Hearth Furnaces	CO ₂ = 6.00 to 11.60				475 to 500°
	Reheating Furnaces	CO ₂ = 6.00 to 10.00				273
	Boilers and Economizers	CO ₂ = 8.40 to 10.40				260

Heating Furnaces and Annealing Furnaces

Critical Comparison of Pair (Sheet Bar) and of Mill Type Furnaces—Sheet Bar Furnaces Are Continuous.

By W. TRINKS

PART XXIX.

IN the preceding installment mention was made of the fact that very little change has been made in sheet and tin plate furnaces, but that sheet bar furnaces had been made continuous, because sheet bars lend themselves somewhat better to mechanical handling than sheets do. It is not feasible to lay sheet bars down flat on a hearth and to push them along, because they would climb over each other. The bars must be placed in a different position for successful pushing. This problem has been solved in two different ways by Allis and by Costello.

at the point of contact between succeeding charges, and climbing over each other is positively prevented. The bars are finally pushed on a sort of forehearth, where the heater can spread them out for the purpose of obtaining an absolutely uniform temperature. The very existence of this forehearth seems to indicate that the bottom bars of each pile are not heated as highly as the top bars and that a temperature equalizing forehearth is desirable.

As a rule Allis furnaces have been fired by stokers, but any other method of firing which will not injure the

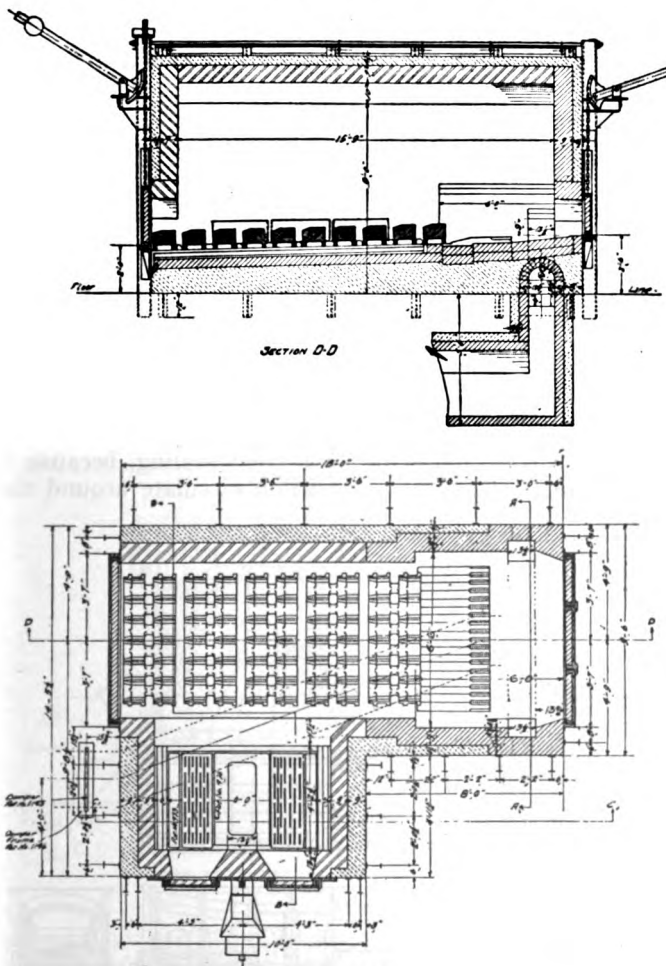
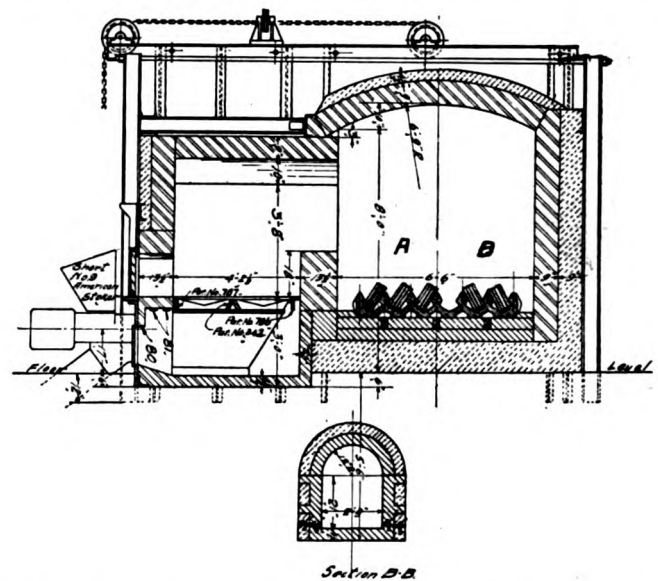


Fig. 220.

The Allis furnace is shown in detail in Fig. 220 and in a more general manner in Fig. 221. It is built by the G. J. Hagan Company, Pittsburgh. The sheet bars are laid in inclined piles on a rack outside the furnace, between the latter and the pusher. See Figs. 221 and 222. A motor operated pusher shoves the bars into the furnace and pushes all of the other piles ahead. Alternate rows of bars stand in different directions. If those on the outside rack slant upward to the right, as in Fig. 222 or at A in Fig. 220, the bars in the charge ahead slant upward to the left, as at B, in Fig. 220. The sheet bars are crossed



sheet bars is equally well adapted. It will be noted from the illustrations that the firebox is at the pusher ends and that the flue gases leave at the other end, where the sheet bars have their highest temperature. This arrangement makes for a fairly uniform temperature in the furnace and protects the bars from being overheated. However, it does away with the fuel saving feature of the counter-current continuous furnace. It is also evident that the location of the firebox to one side results in a one-sided temperature distribution, which is, however, somewhat equalized by radiation.

The principal advantage of the Allis furnace is, of course, the labor saving feature. On the other hand it is claimed, by some mill managers, that this is a rather imaginary advantage, because the wage schedule calls for a given wage per ton for heating regardless of the type of furnace. The before-mentioned mill managers reason that, if you pay a man a good wage for heating, you might as well make him work for it, particularly if the labor saving furnace costs considerably more than the ordinary furnace on account of the royalty which must be paid on its patented features. Another feature which is complained of occasionally, but which can hardly be of deciding importance, is the amount of sheet bars left at the end of a turn (or shift). Heaters object to leaving so much steel in a furnace at the end of a turn. It is

obvious that no steel is being removed from the Allis furnace while a heat is being worked out from the sheet furnace. In other words the continuous furnace is somewhat limited in value, if the charging and removing must necessarily be intermittent.

The latter objection, as well as some of those before

a few bricks out under the skid pipes, thus offering a short circuit to the hot gases. However, it is claimed that the heating is equally uniform with and without these auxiliary openings. It is evident that the sheet bars will topple over near the discharge end, and that the last one will lie flat. This circumstance is quite liable to produce

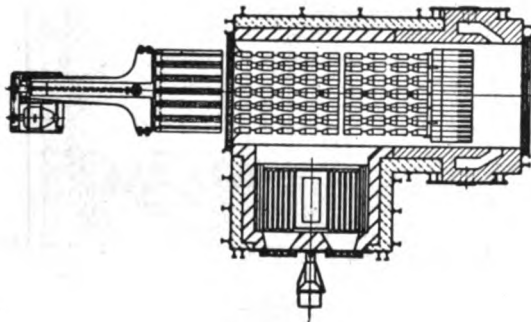
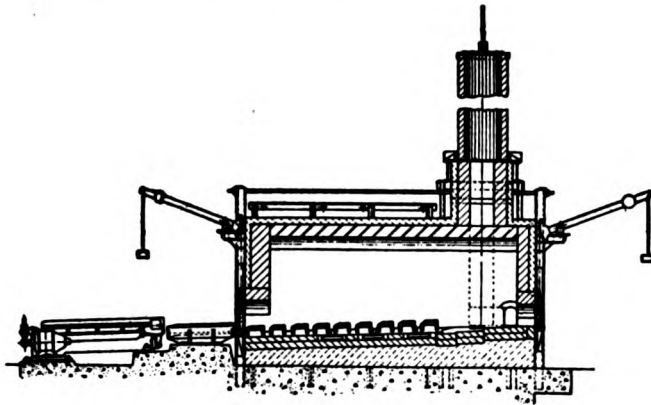


Fig. 221.

mentioned, apply also to the Costello furnace which is shown in Fig. 223. It will be seen that this furnace (which is built by Tate-Jones & Co., Pittsburgh) has some advantages over the Allis furnace. The heating chamber is at the side, just as it is in the Allis furnace, but the furnace is narrower, which fact helps to produce a uniform temperature distribution. The hot gases sweep over the sheet bars and return underneath; in consequence, the fuel is used to better advantage. The sheet bars stand on edge, except the last few near the discharge



Fig. 222.

door. The result is that some of the gases or products of combustion filter through between the bars and heat them more uniformly all of the way through. It might be thought that this statement refers to the center part (between the skid pipes) only and that uniform heating of the overhanging ends could be obtained only by taking

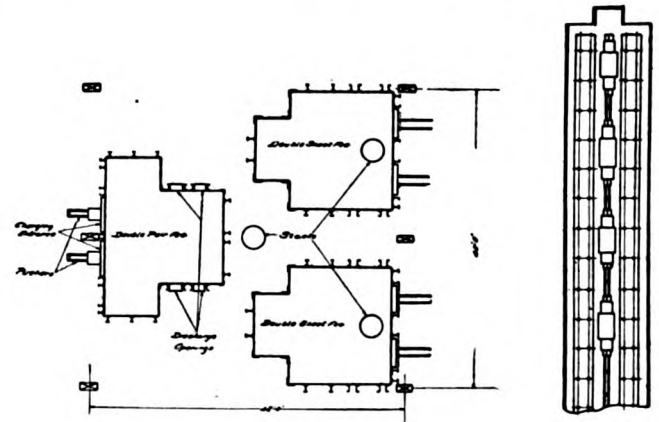


Fig. 224.

climbing and piling. However, the nearness of the discharge door allows straightening up of the trouble with little effort.

The Costello furnace is open to the objection which is common to all furnaces with water cooled skid pipes, namely, "black spots." However, this trouble is considerably reduced, and almost entirely eliminated, in the present furnace, by making the skid pipes double, which means that a small water cooled pipe lies inside a larger pipe which is indirectly cooled by the smaller pipe. It is claimed that this design does away with black spots.

The Costello furnace requires good combustion practice if the bars are to be kept from scaling, because it makes the products of combustion circulate around the

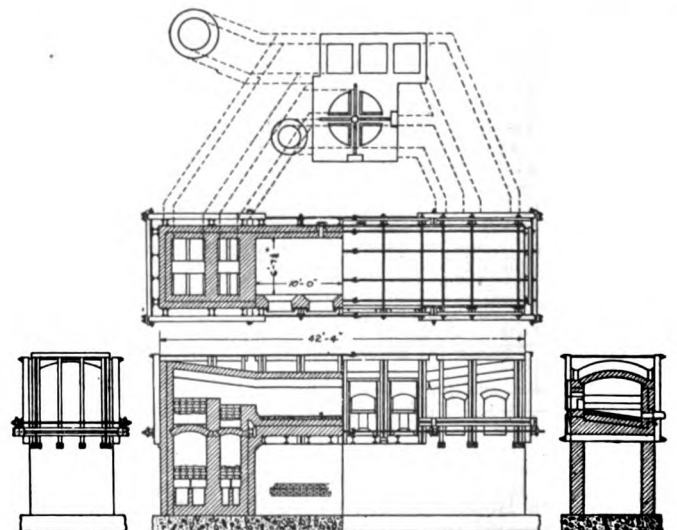


Fig. 225

bars and percolate between them, while in the Allis furnace, heating occurs mainly by radiation, and less by direct contact between gases and steel.

The arrangement of Costello continuous pair furnaces in relation to sheet furnaces and to the mill is shown in Fig. 224.

The last group of furnaces which will be subjected to a critical comparison, is that of mill type furnaces, or "reheating furnaces." These furnaces heat semi-finished material such as blooms, billets, slabs or beam blanks. Although it is commonly known, it may be advisable to repeat here that for numerous reasons it is frequently impossible to finish steel sections in one heat from the ingot. In that case the semi-finished material is charged cold and is brought up to 2200 or 2250 degrees F. in "reheating furnaces".

Two general types are used, namely, "in-and-out" furnaces and continuous furnaces. The meaning of the two terms is clear from former articles. Either one of

cooling of the grate bars and results in burning out of the bars. With powdered coal, blowing or transportation air (which roughly equals one-half of the total air) cannot be preheated. Besides, recuperators and regenerators are clogged up by the ash contained in powdered coal. This latter fact depressing the efficiency of coal fired in-and-out furnaces and limits their applicability to localities in which coal is very cheap. This statement does not apply to low temperature furnaces such as sheet furnaces or annealing furnaces.

Mill type in-and-out reheating furnaces are, as a rule, of the regenerative type, if natural gas, water gas, coke oven gas, producer gas or blast furnace gas serve as

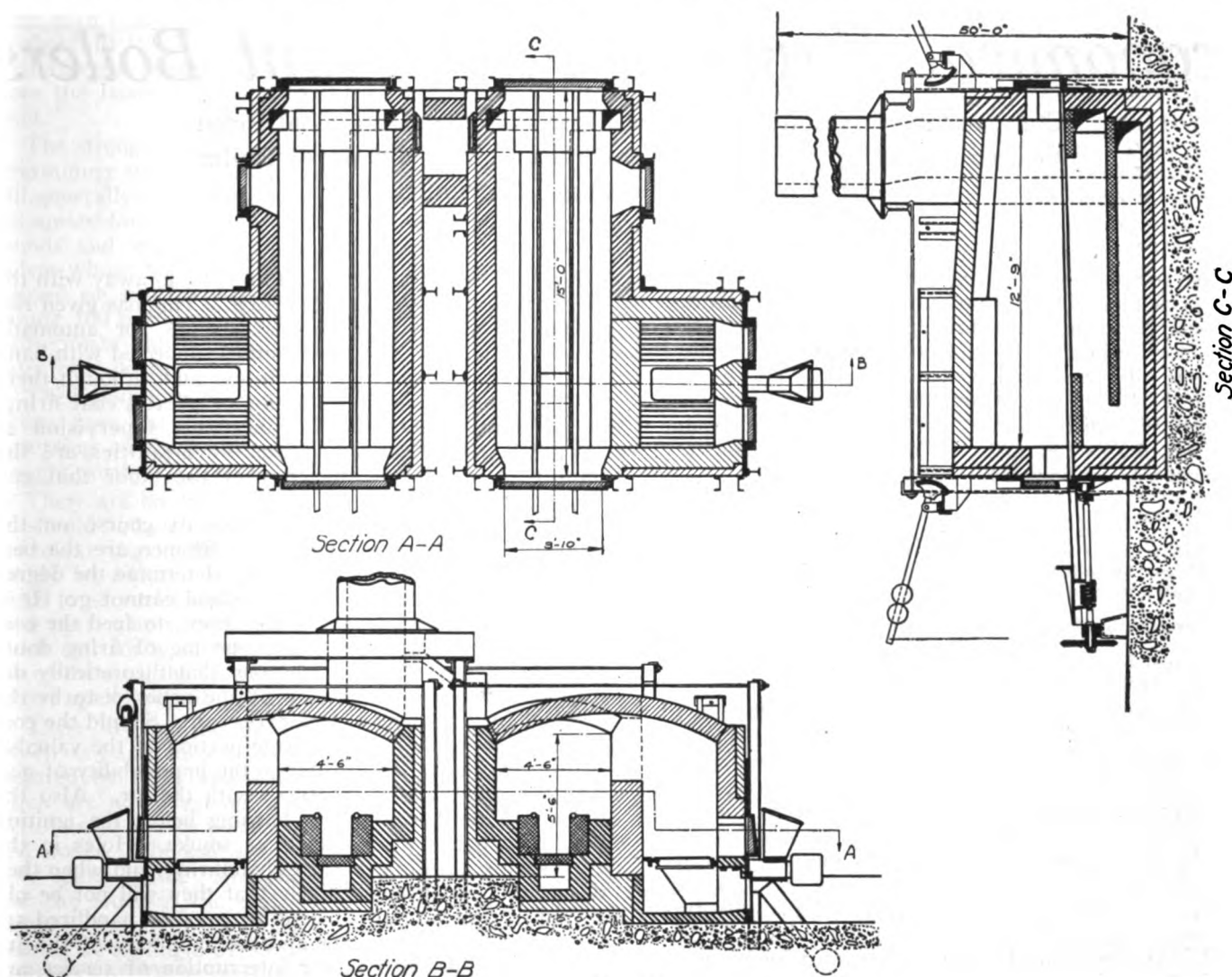


Fig. 223.

the two types can be built with or without means for preheating combustion air by means of the escaping products of combustion, using either regeneration (see Part VIII) or recuperation (see Parts VI and VII).

The plain in-and-out furnace without regeneration or recuperation, which is so common in forge shops, can be found but seldom in modern rolling mills, because of the high fuel consumption. There are, however, some exceptions to this general fact. Whenever coal is used as fuel, either on the grate or else in the shape of powder, preheating of air is impracticable, unless the degree of reheating is extremely small. With coal on the grate, preheat, sufficiently high to be of value, interferes with the

fuels. An example of a regenerative furnace for producer gas is shown in Fig. 225.

The question naturally arises, "under what conditions is the use of that type of furnace advisable?" The answer is best given negatively in this manner: "Whenever it is impossible to use a continuous furnace." In detail, this means that it is used wherever varying shapes or sizes must be handled or with sections which do not lend themselves to being pushed through a furnace. General utility mills, rolling a variety of sections, are almost invariably equipped with in-and-out furnaces. The regenerative in-and-out furnace is likewise used in the heating of skelp and tubes.

The type of furnace under discussion has several undesirable features. The hearth space between the doors is more or less unavailable, particularly in the heating of large sizes which require a charging machine. This fact reduces the capacity of the furnace and causes the designers to keep the posts between the doors quite narrow. But narrow posts have no strength, and collapse, either from unequal expansion or from impact during charging or emptying. Besides, flame passes out around the doors, and the binding of narrow posts is soon burnt away. For this reason it is not safe to figure on heating more than 60 or 70 pounds of steel per square foot an hour. It is desirable to make the roof low on the side away from

the doors and to pass more flame along the door side than on the far side, in order to produce uniform heating.

Regenerator chambers are more or less of a nuisance, first, because they gradually clog up, and second because faulty reversing or careless firing-up produces explosions which either wreck the regenerators or else cause them to be leaky, which condition reduces their efficiency to a considerable extent. The upkeep of the regenerator is another item which must be taken into consideration. Cost figures on this item vary in wide limits on account of different fuels, different conditions of ground water level, and different amount of care taken in operating the furnaces.

Economical Firing of Steel Plant Boilers

Comparison of Handfired, Stoker Fired and Powdered Coal Fired Boilers—A Complete Test Recently Run on a 520 H.P. Boiler Fired by Powdered Coal Is Included.

By CHARLES LONGENECKER

IN any comparison of firing methods it is logical that the principles which obtain in burning coal be first discussed. Knowing these principles, it is a simple matter to observe how their application is carried out in a furnace if it be hand fired, stoker fired or fired with powdered coal. Boilers can be divided into two classes; those on which the load is constant and those having a variable load. For the first named class the firing conditions are comparatively simple and the requirements are:

1. A steady and uniform feed of coal.
2. An unvarying air supply properly distributed.
3. Ash removal which shall not interrupt heat generation
4. Means for effecting the above features which in itself shall function uninterruptedly.

Where the load varies the demands are for:

1. A fuel feeding method which shall readily respond to the fluctuating demands.
2. An air supply which shall synchronize in proportion to the quantity of fuel fed.

The third and fourth features are the same as for boilers with a constant load. Other features which, while not connected with the burning of the fuel in the furnace, are nevertheless controlling ones, are those which determine the economical operation of the unit. These are labor cost, repair cost, coal handling cost, etc. In considering these principles it is presupposed that the furnace design is appropriate to whatever method may be employed. Another consideration which must be borne in mind is that a fuel bed is not of a homogeneous nature.

The simplest method for firing boilers is naturally hand firing. Due to lack of economy this method should be employed only in cases where the boilers are of low horse power and a high rating not desired. It is physically impossible to fire boilers of large horsepower by hand with any degree of efficiency. From another viewpoint hand firing is permissible where the cost of the installation of more economical means is not justified by the saving secured.

The disadvantages of this method are high labor cost, low evaporation per pound of coal, likelihood of a fluctuating steam supply, impracticable on boilers of large size. The advantages are simplicity and elimination of initial cost for equipment for mechanical firing. The ten-

dency of today in boiler operation is to do away with the "human element" as far as possible. This has given rise to the invention of numerous schemes for automatic boiler regulation. The uncertainties connected with hand fired boilers mitigate against its use and although there is less labor in either stoker or powdered coal firing, the aim at present is to reduce this supervision as much as is practicable. Other uncertainties are the supply of labor and efficiency of the labor that can be secured.

Hand firing is based altogether of course on the human factor and even where the firemen are the best there are physical limitations which determine the degree of success beyond which this method cannot go. It is impossible, however good the intentions, to feed the coal as uniformly as required. The opening of firing doors increases the excess air far beyond that theoretically demanded and the withdrawing of the ashes disturbs the bed and further increases the excess air. Should the coal be high in volatile matter a large portion of the valuable hydro-carbons will be lost due to the impossibility of getting a proper mixture of these with the air. Also the gases will be cooled before burning below the ignition point and hence will pass off as smoke. Holes in the fuel bed are hard to prevent in handfiring, and when they do occur it is extremely likely that they will not be observed. The advantages where furnaces are handfired are the low cost of equipment and the simplicity of the installation. The chances for interruption of service are reduced to a minimum as long as labor can be secured. The waste of fuel is high and will run from 25 to 50 per cent greater than is the case where stokers or powdered coal firing is employed. Labor cost is the principle item on the cost sheet and this with the loss of fuel must be balanced against first cost in considering any other firing method.

The desirable features where coal is burned on a grate are a fuel bed of even thickness and uniform composition and the ability to maintain these conditions. The stoker is more economical due to the fact that it more nearly approaches this ideal condition. It can readily be appreciated how hard it is to maintain these conditions in hand firing.

Concerning the limiting size of boiler which can be

hand fired there is much argument. The Coal Trade Journal of December, 1919, states on this point: "This will depend a good deal on local conditions, but within reasonable limits we are able to get a figure which will fit the average case. The city of Cincinnati by ordinance limits the size of a hand fired furnace to 150 boiler hp. This size unit will have a grate surface 6 ft. wide by 6 ft. 6 in. long. It has been pretty well established in practice that a grate 6 ft. 6 in. or at most 7 ft. long is about the economical limit for a hand fired furnace. A longer grate than this will be very difficult for the fireman to handle. A furnace consuming 150 boiler hp is about the comfortable limit of a fireman's capacity. A 300 hp horizontal water tube boiler would have a grate surface not more than 7 ft. long and the width of the boiler would be about 10 ft. This is equivalent to two 150 hp hand fired furnaces under one boiler but is not good practice from the labor standpoint nor from the smoke standpoint."

The strength of draft and characteristics of the coal determining the thickness of the bed, but this thickness will generally run from 4 to 8 inches. The coal burned per square foot of grate surface per hour will average 25 pounds and vary from 10 pounds to 40 pounds under boilers whose horsepower averages 150. The rating developed on such boilers will vary but will usually be around 100 per cent. Average draft in the furnace will approximate .30 inches of water. The above relates to water tube boilers.

The inability of hand firing to meet the above specifications gave rise to the stoker and with the intention of improving on the stoker powdered coal firing has been brought forth.

There are no "hand and fast" rules as to which boilers should be hand fired and which should be stoker fired due to varying conditions but boilers from 200 hp up can readily be adopted to stokers. No one stoker will be suited to all varieties of coal but each will serve best with some particular variety. The characteristics of the coal which call for a variation in the type of stoker are the size of the coal, the fusibility of its ash, its coking powers, percentage of volatile matter and percentage of ash.

There are on the market several types of stokers known as hand stokers. These are as the name implies operated by hand and fed by hand but have features which are advantageous. The grate surface is sloping and the coal can be pushed forward as in a power operated stoker. The ash is dumped from the grate by operating hand levers. An ignition arch is usually sprung over the front of the grate which serves a very useful purpose. In one make of hand stoker the grate bars are inclined at an angle of 30 per cent. It is recommended for boilers of 500 horsepower or less and it is claimed that overload of from 75 to 100 per cent can be carried successfully using natural draft. In a test recently carried out on a hand fired stoker the following results were obtained:

Grate Surface	51.1 square feet
Calorific value per pound of coal as fired.....	12,990 Btu.
Dry coal per square foot of grate surface per hour..	16.23 lbs.
Percentage of rated capacity developed.....	142.8%
Equivalent evaporation from and at 212 degrees per pound of coal as fired.....	10.77
Cost of coal to evaporate 1,000 pounds of water.....	0.247c
CO ₂ in flue gases	10.2%

The earliest mechanical stoker was patented in 1841 and was of the chain grate type. This type of stoker is especially adopted to burn small size coal, and coke breeze, and fire burning coal high in volatile matter. An igni-

tion arch is always provided to assure early ignition of the coal. Elasticity of feed is readily obtained by varying the thickness of fuel bed, the speed of the grate travel and draft in furnace. Fuel bed thickness will average 7 inches and grate travel from 4 inches to 12 inches per minute depending on boiler power demands. Chain grate stokers, are being used very extensively for burning the fine anthracite coal secured from the creeks and rivers which flow through the anthracite coal fields.

Besides the chain grate stoker the underfeed and side-feed types are most frequently found. On boilers of large horsepower the multiple type underfeed stoker is most popular. Under such boilers one retort is provided for each 70 to 100 hp and capacities as high as 400 per cent of rating obtained. A rating of 500 per cent can be secured should enough retorts be installed. Probably the most authoritative test on boiler of large size is that made by Dr. Jacobus at the Detroit Edison plant in 1911 (Trans. A. S. M. E., Vol. 33). Here Sterling boilers of 2365 hp rating equipped with 26 retort Taylor stokers gave an efficiency of 76 per cent at 200 per cent of rating and at 100 per cent rating the efficiency was 80 per cent. In "Power," June 23, 1914, the following are given as the controlling factors influencing the efficiency of a stoker.

1. The size of the unit.
2. Percentage of overload.
3. Character of coal.
4. The use of indicating boiler room appliances.
5. Intelligence of the fireman.

"The factor of most importance is, without doubt, the degree of intelligence which the fireman possesses and the interest he takes in improving operating conditions."

It is hard to see how there can be a much greater development of the stoker as it has its limitations beyond which it cannot go. One of these is the exposure of the parts to the intense heat of the furnace. At very high ratings the amount of coal burned per hour is great and the heat produced is correspondingly high. At high temperatures the ash fuses and is hard to dispose of properly and there is also liability of trouble arising from some coating of the tubes with the small particles of pasty ash. This ash is carried up by the gases which travel at a high velocity which is created by the increased air pressure demanded when large amounts of coal are burned. If larger boilers are built other means than the stoker must be employed to supply the coal. Whether larger boilers are practical is a debatable question but the trend has been towards increased size of units as is evidenced by the recent installation at the Ford plant. The boilers in this plant are of 2647 horsepower, and will be fired with blast furnace gas or powdered coal.

The mechanical power operated stoker unquestionably fulfills the requirements previously mentioned more perfectly than any other method other than powdered coal. With it the feed is uniform and the rate of feed can be varied as desired. The air supply more nearly approaches the theoretical and ash removal is regular and uninterrupted as long as the machinery is in operation. The limiting features are the coal characteristics and the conditions under which the particular type of stoker must operate. Certain types of stokers are adopted to burn certain varieties of coal and if for any reason a coal is obtained which has qualities other than those for which the stoker is adapted trouble may arise. Where forced draft is employed a high rating is easily obtained provided furnace volume is sufficient and the stoker will handle the increased amount of coal efficiently.

The use of powdered coal as a fuel for boilers is un-

questionably making rapid headway. There have been many obstacles to overcome but this has been true in the solving of most engineering and metallurgical problems. When it is recommended that in 1913 the hourly coal pulverizing capacity of metallurgical plants was only 20 tons per hour it is evident that the industry is still very young in years.

Powdered coal firing takes precedence over the stoker in meeting the first two requirements before mentioned. The coal being in a fine state of division can be introduced into the furnace very uniformly and steadily and the air supply proportioned very closely to the theoretical. In all systems the coal is carried in a current of air from the burner so that intermixture can be very exact. The ash removal has occasioned much experimenting in order that it might be done successfully. The result of these experiments have proven beyond doubt that the correct disposal of the ash is a question of furnace design and draft regulation. For different coals alterations must be made depending on the burning characteristics. Interruption of feed is so seldom that it need not be considered as installations of the present day are mechanically very efficient. The lining feature for powdered coal firing is the size of the plant or the horsepower of the boilers. Where these total under 2,000 hp there is a question as to whether the saving will justify the cost of installation. There is no doubt but that this limiting feature will be overcome as progress in the art is made.

One of the greatest advantages connected with firing of powdered coal is the quick response which can be made to an increase or decrease in the load. By simply opening a valve it is possible to secure the immediate introduction of more fuel or to cut off the supply. This makes this method of burning coal very attractive, especially where the load fluctuates rapidly.

In a paper recently delivered by George T. Ladd before the Engineer's Society of Western Pennsylvania, the following statement is made in connection with the boilers, previously mentioned, as installed at the Ford plant. "The possible capacity ratings when burning powdered coal will be extremely high, as the firing equipment is of such a capacity as to burn completely sufficient coal to produce 400 per cent rating continuously. It is probably that a high percentage of efficiency will be maintained throughout the whole cycle of operation, as the efficiency curve when pulverized fuel is properly handled is very flat from 50 per cent to 400 per cent of normal rating. From the above, attention can logically be drawn to the high capacities possible with extremely large units when equipped for burning pulverized fuel as the main system of firing, without attempting consideration of the enormous furnace widths that would be required for stoker firing.

The following is a test recently run on a 520 hp boiler fired by powdered coal. This test was made to determine the results which could be expected under normal operating conditions.

Dimensions.

2. Number and kind of boiler—1 Babcock & Wilcox.
3. Kind of furnace — Pulverized Fuel Burning Furnace.
4. Volume of combustion space per boiler 2,000 cu. ft.
5. Water heating surface in boiler.... 5,201 sq. ft.
 - (a) Water heating surface in economizer.
 - (Ordinarily serve two boilers) 3,931 sq. ft.
6. Superheating surface 943 sq. ft.
7. Total heating surface of boiler.... 6,144 sq. ft.
 - (a) Total heating surface of boiler and economizer 10,075 sq. ft.

- (b) Ratio of water heating surface of boiler to volume of combustion space 1 to .198
8. Date 6-15-20
9. Duration 23 hours
10. Kind and size of coal..... Bituminous coal

Average Pressures, Temperatures, Etc.

11. Steam pressure by gauge..... 87.7 lbs. sq. in.
 - (a) Barometric pressure 29.56 in.
12. Temperature of steam 447.1 degrees
 - (a) Normal temperature of saturated steam 329.4 degrees
13. Temperature of feed water entering boiler 166 degrees
 - (a) Temperature of feed water entering economizer 66.3 degrees
 - (b) Increase temperature of water due to economizer 99.7 degrees
14. Temperature of escaping gases leaving economizer 252. degrees
 - (a) Temperature of gases, top of third pass 474. degrees
 - (b) Temperature of gases, bottom of second pass 552. degrees
 - (c) Temperature of gases, top of first pass 939. degrees
 - (d) Temperature of bottom of combustion chamber 2312. degrees
15. Draft between economizer and fan. 1.37 in.
 - (a) Draft top of third pass..... .35 in.
 - (b) Draft bottom of second pass.. .15 in.
 - (c) Draft top of first pass..... .02 in.
 - (d) Draft in combustion chamber. .26 in.
 - (e) Blast pressure 5.72 in.
 - (f) Differential pressure in blast pipe 5.64 in.
16. State of weather Cloudy and rain
 - (a) Temperature of boiler room... 90. degrees
 - (b) Relative humidity of air entering furnace 80%

Quality of Steam.

17. Number of degrees of superheat.... 117.7 degrees
18. Factor of evaporation based on temperature of feed water entering economizer and degrees superheat. 1.251
 - (a) Factor of evaporation based on temperature of water entering boiler and degrees of superheat 1.149
19. Total weight of coal as fired..... 54,994 lbs.
20. Per cent of moisture in coal as fired .94%
21. Total weight of dry coal..... 51,694 lbs.
22. Ash and refuse (dry).....
 - (a) Withdrawn from furnace bottom, tubes, flues and combustion chamber 2327.6 lbs.
 - (b) Blown away with gas..... 6727.5 lbs.
 - (c) Total 9055.1 lbs.
23. Total combustible burned 42,637 lbs.
24. Percentage of ash and refuse based on dry coal
25. Total weight of water fed to boilers 467,423 lbs.
26. Equivalent evaporation from and at 212 degrees, based on temperature of water entering economizer, corrected for superheat in steam..... 584,746 lbs.
 - (a) Equivalent evaporation from and at 212 degrees, based on temperature of water entering boiler 537,067 lbs.

Hourly Quantities and Rates.

27. Dry coal per hour..... 2247.5 lbs.
28. Dry coal per cubic foot of furnace volume per hour 1.123 lbs.
29. Equivalent evaporation per hour from and at 212 degrees, based on water entering economizer..... 25423.7 lbs.
 - (a) Equivalent evaporation per hr. based on temperature of water entering boiler 23350 lbs.
30. Equivalent evaporation per hour from and at 212 degrees per sq. ft. of total heating surface, based on water entering economizer 2.52 lbs.

(Continued on page 336)

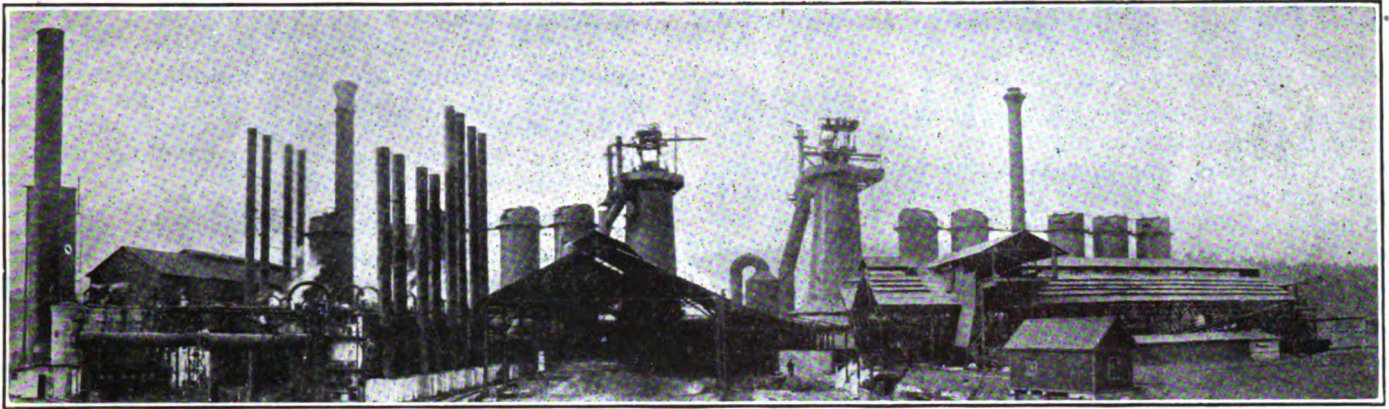


Fig. 1—General view of blast furnace plant.

The Alabama Company Nineteen-Twenty Improvements At Gadsden, Alabama

Improvements in Design, Lines and Distribution of Number One Furnace—New Storage Trestle—Locomotive Cranes—Installation of Pig Casting Machine—Labor Reduced From 305 to 160 Men.

By H. R. STUYVESANT,
General Superintendent, Blast Furnace Department.

FOR the past year the Alabama Company has been steadily improving its blast furnace plant at Gadsden, Alabama, near Birmingham. Number one furnace was of old design with petticoat, tuyere breast and hearth jacket spray cooled with a ditch encircling the hearth jacket and extending down to the level of the tapping hole. Cooling is not efficiently effected with this type of hearth, especially below the ditch. Practice shows that breakouts with this type of jacket are frequent. The breakout assumes more serious consequence on account of the jacket being surrounded by a ditch containing water. The iron coming in contact with the water causes violent explosions and heavy concussions with results which are disastrous as well as expensive. This danger has been so repeatedly demonstrated throughout the country that it was decided to eliminate the ditch entirely and abandon the idea of surface cooling.

Number one furnace was blown out October 19, 1920, and work of dismantling was immediately started. The shell was in good condition as were the foundation, columns and base plates. After removing the lining, the old iron work of hearth and bosh was dismantled, and five feet of iron, running silicon 1.25, sulphur .045, manganese .49 and phosphorous 1.11, was removed from the hearth, and the bottom built up with five courses of standard 18 x 9 x 4½ bottom blocks. No leveling was required to the furnace shell and mantle, as they were found to be correct.

Both on account of the inferior design of hearth and bosh construction, and on account of changing the lines of the furnace, entirely new iron and steel work was placed beneath the mantle as described.

The hearth section is of one and one-half inch rolled steel plate, butt strapped, riveted both externally and internally. Cast iron cooling plates, four inches in thickness, with two U tubes of one and one-

half inch extra heavy pipe cast in same, are placed continuous about the entire circuit of the hearth jacket, extending to the bottom of the rolled steel hearth jacket. A small packing space was essential between the outside hearth jacket and the cooling plates, on account of the rivet heads on the steel jacket and the space between the butt straps. This space was packed tightly with a dry mixture of granulated slag and loam, the brick being laid solid against the cooling plates. Fire brick was built solid from outside bottom of hearth jacket to ground level, extending to center line of columns encircling the entire hearth jacket. This aids to further protection in case of possible failure of the high quality brickwork, workmanship, effective water cooling and mechanical strength. Enough clearance was provided for expansion to eliminate possible chance of side thrusts on the columns. Only a small run-off trough for occasional waste water is provided. To strengthen the bosh at the tuyere section a one and one-half inch rolled steel tuyere breast was used, being supported by the hearth cooling plates, holes being cut in for cooler and plate openings, as the most critical actions and highest temperatures are around this area. Strengthening at this section aids in the eliminating of so-called cinder breakouts, with which most every furnace man is familiar, especially where no protection to this section is provided except bosh bands. Three rows of cooling plates and ten tuyeres affords efficient cooling to this section.

The bosh bands, seven in number, are of one and one-half inch rolled steel. In order to prevent slipping of the bosh bands, forged steel bosh band supports were used which link the entire bosh band section together. The top band support is hung from the mantle ring, while the lower band support rests on the tuyere breast, dividing the weight of the bands between the mantle ring and the tuyere breast. Cool-

ing is effected in the bosh section by seven rows of bronze cooling plates, 20 in each row. The bronze cooling plates were all arched over.

The cubical capacity of the furnace was slightly increased, the bosh was lowered and made steeper, the hearth diameter was increased, the batter of the in-wall was increased, giving the furnace approximately 78 degrees bosh angle as compared with the pre-existing bosh angle of 74 degrees. The top, which is of Brown type, but of an old design was improved, the distribution was corrected by placing an extra receiving hopper with a throat extension between the skip and the revolving chute, thus causing the material to pass centrally through the throat of the new receiving hopper onto the revolving chute which now distributes the material on the big bell uniformly, irrespective of the position of the chute.

Improvements in design, lines and distribution of number one stack assures a much better and more economical working furnace, thus eliminating disastrous explosions from possible breakouts and assures an increased production, which necessarily reduces the operating cost.

The P. J. Brown Construction Company of Cleveland contracted the brick work. Harbison Walker

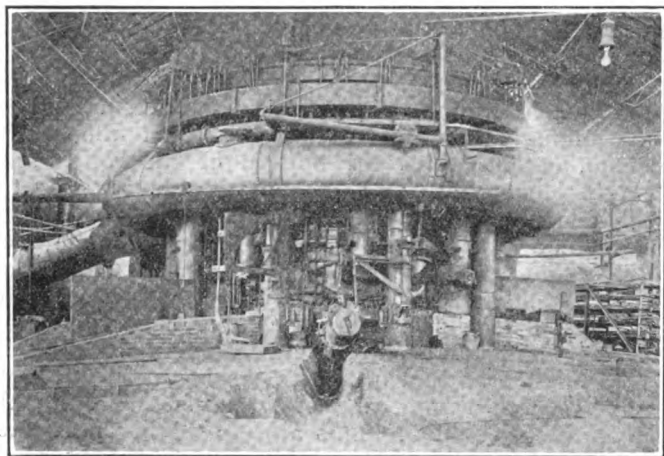


Fig. 2—Base of the furnace.

Refractories Company furnished the brick for lining. The Variety Iron Works of Cleveland fabricated the hearth jacket, tuyere breast and bosh bands. The construction was done by the regular mechanical force, the designing and construction being in charge of the writer. Work on the furnace was completed January 1, 1921.

New Storage Trestle.

To insure a continuous run on both furnaces, eliminating the necessity of depending on the railroads to deliver raw materials, and as a further protection against mine and railroad troubles, a new permanent storage trestle was built and an ample supply of raw material stored for emergency needs. The trestle is designed so as to chute the materials to the side of same, eliminating the evil of filling the space under the trestle, this evil having a marked tendency to rot away the trestle and also requires excess labor in the recovery of materials. With the chute design of the new trestle the recovery of all material is available with locomotive cranes.

Locomotive Cranes.

Two 20-ton "Link-Belt" locomotive cranes are employed. Number one crane is equipped with a 36-inch Ohio lifting magnet and is used in the iron yard. Number two crane is equipped with a clam shell bucket and is used in general for handling ore, coke, stone, sand, ashes, cinder, etc.

Installation of Pig Casting Machine.

To insure a clean and uniform pig, both physically and chemically, together with doing away with the evils inherent in sand cast pig iron, a pig casting machine was installed. The installation includes a Heyl and Patterson pig casting machine of the most improved design of single strand Uehling type. The installation is so arranged that an additional casting strand can be readily installed to give a double strand casting machine, if necessary. The iron from the furnace is run into a ladle having a capacity of 75 gross tons. The ladle is of standard type with lifting trunnions. An overhead crane of Heyl and Patterson two-standard motor type, having a capacity of 55 net tons, tilts the ladle, pouring the iron into a runner which leads to the pig machine moulds. The flow of the metal is regulated to a nicety by the crane operator. The casting machine is driven by a 20 hp motor, cooling is effected by two lines of spray pipes over casting strand, the sprays extending a distance of 75 feet from the head of the machine. At the head of the machine the iron leaves the mould, passing directly through a chute into railroad cars. For cooling the iron after being loaded into cars a 35 foot steel trough is suspended over the loading track. The iron is then either shipped direct or transferred into other cars by a Link-Belt locomotive crane equipped with a 36-inch Ohio lifting magnet. In the event the iron is to be loaded into box cars, table chutes are provided in the iron yard for this purpose.

General.

In order to increase the efficiency of the locomotives and the locomotive cranes, assuring same in coaling up in the shortest possible time, a new coal storage with chutes was built.

A railroad track was extended into the boiler house in order that coal could be unloaded from cars directly at the point of use, also in order that ashes could be loaded directly into cars provided for this purpose.

All material storages, including sand, clay, coke braize, lime, fire brick, etc., were located at point of use, thereby eliminating the necessity of excess labor required for rehandling.

Two first-aid teams composed of six men each, have qualified in the work, having been instructed by a government agent.

In conclusion, from the foregoing improvements, organization and system, the pre-existing labor force of 305 men, required to operate two furnaces, was reduced to 160 men. However at present the company is operating its number two furnace only with 112 men as compared with 175 men formerly used to operate one furnace.

TUNGSTEN IN 1918.

A bulletin was recently received from the United States Geological Survey on "Tungsten in 1918." It discusses production, prices (their cause and effects) substitutes and the control of the world's supply.

By-Product Yield From Fifteen-Year-Old Coke Oven Plant

The Tuscaloosa, Alabama, Plant of the Semet-Solvay Company—
Operated in Conjunction With the Central Iron & Coke Co.,
Still Maintain a High Efficiency in Production.

By W. L. GRAUL,
Semet-Solvay Company, Holt, Alabama.

STUDENTS of the by-product coke oven industry have shown increasing concern over the apparent inability of many of our coke oven plants to maintain satisfactory yields of by-products after the plants have attained an age of about eight years or more. It must be admitted that in many cases their concern is justified. Apparently the results expected were obtained from a plant only while it was comparatively new and continued operation in many cases resulted in a steady decrease of yields of the desired by-products.

However, recent records indicate that the relatively low by-product yields from a comparatively old plant are by no means unavoidable. An opportunity presented itself during the past summer to study carefully the operation and results on one of the

are five flues high, or about nine feet inside dimension, 35 feet long and from 16 to 17 inches wide, with a theoretical capacity of nine tons per charge. In this type of oven, a sole flue is provided, and the heat in the waste gases is recovered in waste heat boilers which furnish an ample steam supply for the entire plant.

In 15 years' operation, it has never been necessary to shut the block down for repairs to ovens or even linings. With this type of oven, such repairs as have been necessary, have been made by shutting down individual ovens for a few days without interfering with the operation of adjacent units.

The plant in general has gone through rather more than the usual vicissitudes developed by variations in demand for coke. Very seldom was it possible to

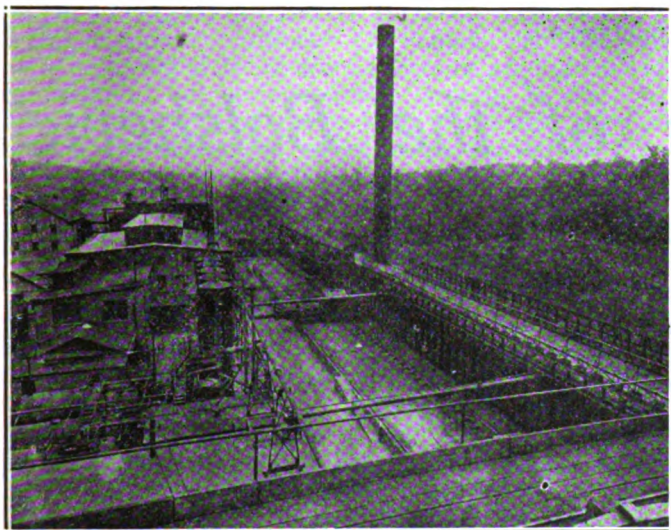


Fig. 1—General view of the plant.

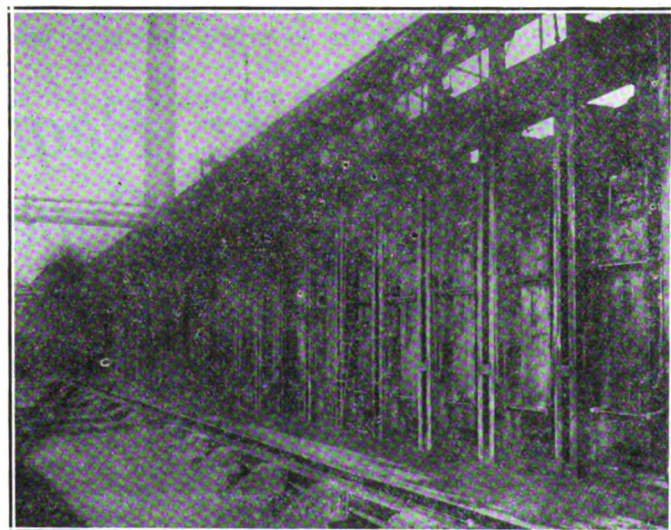


Fig. 2—Semet-Solvay ovens 15 years old.

oldest blocks of by-product ovens in the country. The situation came up in this way:

The Tuscaloosa, Alabama, plant of Semet-Solvay ovens is operated by the Semet-Solvay Company in conjunction with the blast furnace operation of the Central Iron & Steel Co. Demands for coke decreased to such a point that it seemed advisable to shut down the more recently built block of 20 ovens, inasmuch as the output of the old block of 40 ovens was sufficient to meet requirements. This was done and during the months of June, July, August and September, 1920, under particularly trying weather conditions in Alabama, the old block alone was in operation.

This block was built in 1905 and consists of 40 of the then standard Semet-Solvay cold air ovens. They

maintain the same average rate of operation for two consecutive months. Market conditions have forced the operation to change from a pushing rate of only 15 ovens per day to 50, 60 or 85 in a comparatively short length of time. With these figures in mind, it will be seen that the plant certainly has not been favored by operating conditions.

The coal used is of excellent coking quality, and as will be seen in the table below, average about 30 per cent volatile matter. It differs, however, from the best by-product coking coals of the north in that instead of the usual low ash content of from four to seven per cent expected in the best northern coals, the coal used during the period in question averaged over 10 per cent ash. It may be remembered that in

spite of this, high ash content, the coke made at the Tuscaloosa plant, and iron made using it by the Central Iron & Coal Co. furnace were both awarded silver medals at the Panama Pacific Exposition.

Bearing in mind the age of the block in question, the fact that it has never been down for oven repairs, the extreme variations in operation to which it has been subjected, and the high ash content of the coal furnished it, the figures given below take on added interest.

Month	Coal			Yields		
	Percent Volatile	Ash	Total Coke	Ammonia (As lbs. Sulphate)	Gals. Light Oil	Gals. Tar
June, 1920	30.43	9.06	72.55	26.75	3.42	10.55
July, 1920	29.14	10.60	72.87	27.14	3.28	10.14
August, 1920	30.31	9.98	71.80	26.28	3.28	10.06
Sept., 1920	30.19	11.27	71.13	25.63	3.28	9.89
Average	30.02	10.23	72.09	26.45	3.31	10.16

These figures indicate returns not only much better than those reported from some batteries of different design constructed within the last 6 to 12 years, but also comparing well with the returns from some plants of very recent construction. The block was operated during the period in question at well over 100 per cent of rated tonnage and the ovens were taking a greater charge of coal than their theoretical capacity.

In spite of decreasing returns from some of the other plants, conclusions from a survey of all these factors in the performance of the Tuscaloosa Semet-Solvay block, would seem to prove that a decrease

in by-product yields coincident with increasing age of a coke oven plant, has been, and can be, prevented by proper design, construction, maintenance and operation.

Every coke oven operator recognizes the necessity for proper operation and maintenance of his plant, since the results of mistakes along those lines are always painfully evident. Faulty construction is also generally very apparent sooner or later. Improper design is, however, more difficult to discover, due largely to the fact that the operator usually is too much concerned with the immediate necessity of making his plant produce results to worry over the question of whether or not its fundamental design is the best obtainable. It is only after a period of years has elapsed and the operating results can be compared with similar results from a plant of different type, that the problem of the best design is considered. It is perhaps unfortunate that such is the case, since the investment in a coke oven plant is relatively so large that the question of what design will give the best returns over a long period should be of paramount importance, but experience is always slow and sometimes costly and it only remains to use to the best advantage such experience as may be available.

This brief article has been written with that end in view—to furnish information concerning the actual results obtained, not during any particular test, but in the ordinary course of operation of a Semet-Solvay plant after 15 years of the usual coke oven plant operation.

The Donetz Region of the Bolshevic Government

By DIRECTOR M. ULLRICH.

PART II

NOTE—We are recommending this article to the special attention of our readers. The author was employed in an iron and steel industry of the Donetz region and his work from September, 1918, to October, 1920, with the Soviet government of the Ukraine as assistant to the director consisted in furnishing technical material to the Donetz region. In this capacity he has had wonderful opportunity to become thoroughly acquainted with the conditions described by him.

AT the present time, one blast furnace is in operation in the Russian-Belgium steel works in Jenakijewo and the second one in the Union in Makejewka. Here a few mills roll plates and structural material. In addition, one mill is running in the Kramatorskaja which produces billets, but the production of rolled material is so small that it cannot come anywhere near filling the tremendous want for plates and other rolled material. There is no wire for the production of nails which have disappeared entirely from the warehouses so that the necessary buildings and repairs cannot be made. On account of lack of wire no nets can be made for the safety lamps of the miners, so that the latter will very soon be compelled to work with unprotected lamps underground and to expose themselves to the greatest dangers. There is no foundry iron, and no pig iron suitable for open hearths, which cannot be produced

in the required quality on account of the lack of the necessary raw material and of skilled workmen. It is true that in the large steel works there can still be found several million puds of pig iron scrap of unknown quality which cannot be used anywhere. Up to the present time the Bolsheviki have used the stores which were bequeathed to them by the Czar government but these now are almost entirely used up. Wages in the iron and steel industry have lately gone up tremendously as the following tabulation from the actual record from the Kramatorskaja steel works proves:

	Number of Workmen	Wages Paid per Month
July 1, 1919	2,262	885,775.00 Rubles
October 1, 1919	1,368	802,507.63 Rubles
January 1, 1920	1,440	759,188.00 Rubles
April 1, 1920	1,368	3,033,877.47 Rubles
July 1, 1920	1,454	6,094,611.65 Rubles

With that the production was very small.

	Number of Officials	Salary
July 1, 1919.....	308	279,000.00 Rubles
October 1, 1919.....	251	242,000.00 Rubles
January 1, 1920.....	251	368,000.00 Rubles
July 1, 1920.....	270	1,370,000.00 Rubles

In addition, this company was given for the period of January 1920 to June 30th an extraordinary subsidy of 76 rubles. In connection with this it must be remembered that the expenditures for equipment within this time are not included in the above mentioned figure. For the production of boiler tubes and of gas pipes, the pipe mill of Chaudoir in Jekaterinoslaw has been operated but this works produces almost nothing. Of course, all these works suffer from lack of coal. Works which are fortunate to have their own locomotives bring their coal from the coal region, but even the supply of these preferred works is interrupted very often. Last winter works which are very favorably located in the coal region and were considered as best producers were not in a position to supply their own coal requirements, but were required to shut down their electrical generating stations and to leave their whole works without light or power. Thus the whole condition of industry is undermined by the lack of coal and of raw material, by the breaking down of the transportation equipment and by the unwillingness of the workmen to do any work. The fruitless methods of administration by the bureaucratic authorities allow no improvements of the present conditions. Of course, the situation could be saved if there were a strong administrative organization, but unfortunately nothing is done to gain this end and nobody is here who could bring it about. The operating commissions consist of men who have not the slightest idea of mines and of steel works. The work of the central administration is terribly depressing. The engineers are physically and mentally broken down without rights of protection; they are intimidated victims for insults and oppression.

The Russian transportation system is in terrible condition and its reconstruction concerns the government very much without any signs of a recovery. In the railroads there exist gruesome conditions. About 70 per cent of all the rolling stock is out of operation. The railroad stations seem like grave yards in which the corpses of hundreds of defective locomotives and rusted cars stand or lie around, the repair of which seems to be out of the question for quite some time. It is true that Trotzky says in his order No. 1042, addressed to locomotive repair shops that in 1925 Russia will have again sufficient locomotives and cars; but probably he is not convinced of the correctness of his claim. During the year the number of repaired locomotives in the shops increased a little bit compared to the year before, but during the fall, the work dropped off so much that during the winter the number of the preceding year probably cannot be reached. The reason for the falling off is principally that the locomotive sheds and repair shops could not be repaired or maintained for several years because the necessary building material is non-existent. There is no material available for windows, doors or roofs. There is no glass, no roofing paper, no building cement, and no lumber. It is evident that when the hard winter begins nobody can work in the shops which offer no protection

against the cold and the destruction of whatever rolling stock that is left goes on without interruption.

Just as sad is the condition with regard to the number and strength of horses. Horse feed can hardly be procured and what few horses are still in existence can scarcely be kept alive. The mines have hardly any horses at all, so that coal can be brought to the cages only with the greatest trouble; and then the orders of the Soviet government often contradict each other in the most unintelligible manner. For instance, great herds of horses and mules have been brought from the Kuban section to the Donetz region but were requisitioned by the soldiers as soon as they arrived.

In the Soviet administration Saint Bureaucrats rules absolutely. The organization of the government works with a tremendous apparatus of officials, the working efficiency of which is inversely proportional to their number. The authorities have been utterly ruined by favoritism and work very slowly and improperly. Important requests after lying around for days in wrong departments reach the right department too late; the solution of the matter requires additional, almost endless time until the much desired answer reaches the applicant. Usually the answer and the whole work is without value because the purpose of the petition of the latter has passed out of existence and the whole affair is no longer pressing. The result is that important affairs are only taken care of by confidential go-betweens who take the letters to the proper parties and are duty bound to get immediate reply.

It is peculiar to the method of administration of the Soviet government that the communists who are in good repute with their party, never seem to stay any length of time in one place and, for that reason, there is an everlasting and depressing change in important positions in the Donetz region, which region needs a cautious, energetic and thoroughly experienced administration. This fact explains the miserable result that today after a year of administration practically nothing has been accomplished in the Donetz region. With all that, the administration is too jumpy and full of contradictions, depending too much upon the moods and whims of the directors who have no technical knowledge. Orders of yesterday are cancelled today to make way for new orders tomorrow. Since there is no definite direction by the central administration, work in the individual sections sags and stops. Furthermore, coöperation is made very difficult, if not impossible, by the utterly unsatisfactory conditions of the postal and transportation service.

The output of the workmen in the Donetz region has fallen off deplorably which can be explained from the fact that most of the workmen don't work but occupy themselves principally with secret sales and by the gain resulting therefrom attempt to bolster up their wholly insufficient wages. The official food situation can not be described. The workmen do not even receive sufficient bread to sustain life. To get a supply of meat and fat is out of the question as long as the Bolsheviks rule. Neither the working man's clothes nor his shoes are sufficient. Many of the workmen are almost wholly naked and have no expectation of ever obtaining a suit of clothes or a pair of shoes; but the chief communists stride around in leather suits and in good shoes. These gentlemen also obtain cloth from which good clothing can be

made. On the other hand, the industrial workmen, even if they are communists, walk around in rags and barefoot. The communistic representative, Dr. Levi, said last year in the German Diet that the "Proletariat" nowhere lives as well as in Soviet Russia. But actually the opposite is true; nowhere the workmen face as bad conditions as in Russia. The government imposes compulsory hard labor which is a terrible thing under the present conditions of underfeeding of the men and of their families. With his paltry monthly wages of 6,000 rubles and the usual bonus of 130 per cent, the workmen cannot buy food with the present high prices unless he steals and makes secret sales. All trade lies only in the hands of secret salesmen and the wares are either traded against other wares or else paid for by tremendously high sums of paper money. Thus a very inferior, hardly eatable loaf of bread costs 600 rubels, meat from 1,300 to 2,000 rubles, fat and butter 5,000 to 6,000 rubles a pound, salt 800 rubles a pound, a box of matches 280 rubles, a pound of potatoes 50 rubles, and a glass of milk 250 rubles. The price of clothing is out of sight and a pair of shoes costs 65,000 rubles.

Piece-work which is so often decried by socialism has again been introduced thoroughly in Soviet Russia, because the government has recognized that reconstruction of industry is impossible without it. Important is the observation of what the government does in case of strikes and what its position is towards the unions. A strike is almost impossible in Soviet Russia, because any movement towards obtaining

higher wages or better working conditions is considered a counter-revolutionary act and is treated as such; that is, the leaders are imprisoned immediately and as a rule are shot. It is known that the workmen are very much dissatisfied with the government and will be very glad to shake off the unbearable yoke, but the terrible reign of terror keeps them cowed. They are too powerless and apathetic to revolt against the iron rule. Officers for the protection of workmen do not exist, because the unions are led and conducted by communists, receive their directions from the state, and naturally will not allow anything which might displease the Soviet government. One must therefore be careful not to draw comparison between unions in other countries and those in Russia, as the latter have not the least power or possibility to do anything for the welfare of their members.

With the present condition of production and method of administration, the government is, of course, not in position to offer anything to foreign trade and to import goods of which it is very much in need. Only a change of the system can change conditions and can lead Russia to a new and more happy future which would allow trade in industry to enter into valuable economical connection into Russia and to gain a foothold in the Ukraina as it was before the war. But even the most hopeful human being cannot believe that this condition can be brought about in the near future. The chaos is still much too great.

Large Blooming Mill Motor Drive Completed

The General Electric Company Have Completed a 40-Inch Reversing Blooming Mill Drive for Tata Iron and Steel Company, Jamshedpur, India.

THE General Electric Company has recently completed a 40-inch reversing blooming mill motor drive, complete with reversing motor, flywheel motor generator, control and auxiliaries for the plant of the Tata Iron & Steel Co., Jamshedpur, India. This electrical equipment is of the same type as those which have proven so successful in the plants of the Tennessee Coal Iron & R. R. Co., Trumbull Steel Company, Bethlehem Steel Company and other mills.

The reversing motor is of the double unit type, consisting of two shunt wound motors on a common shaft, and is rated 7,000 hp (50° C rise) at 55 to 120 rpm. Power is supplied by a flywheel motor generator, composed of three 2,700 kw (50° C) generators and one 50-ton (45,000 kg) flywheel, all driven by a direct connected induction motor, having a continuous capacity of 5,000 hp (50°) at 375 rpm.

The motors are of very strong construction throughout, so as to withstand the severe shocks to which they will be subjected. The mill end bearing affords a good example of this construction. This bearing is 30 inches in diameter by 70 inches in length and is mounted in a spherical seat on a cast steel pillow block which also supports a lubricated babbitted thrust plate, against which the motor half of the

coupling may bear in case of a broken mill spindle. The total weight of this complete pillow block, with its bearing and thrust plate, is approximately 61,000 pounds (27,700 kg) and the bolts which secure the cap to the pillow block, and the pillow block itself to the base weighs approximately 2,400 pounds (1,100 kg).

Only the best material is used throughout and full consideration has been given the effect of the frequent reversals of torque. The following brief description of the construction may be of interest.

The shaft is made of a single forging of high-grade open hearth steel, carefully annealed and finished all over, and having the journals polished. The armature spider of each unit is a single steel casting carrying an extension on which the commutator is pressed and keyed, thus preventing all movement between the commutator and armature, and allowing the armature, less shaft, to be handled as a unit. The laminations which form the magnetic circuit of the armature are of special steel, securely dovetailed to the armature spider by an overfill method of assembly which eliminates any possibility of loosening due to frequent reversals. The laminations are stacked under tremendous pressure and secured by end flanges held

by through bolts, which do not pierce the active magnetic material.

The armature windings consist of copper bars, thoroughly insulated with special mica insulation and moulded to exact size before being assembled in the slots, where they are held securely in place by wedges driven into grooves in the teeth. The portion of the windings outside the slots are bound down to the end flanges by sectional binding bands, which prevent displacement due to centrifugal force. This type of band greatly facilitates repairs, as the entire band is readily removed by removing a key between any two sections. A special clamping device is supplied for replacing the band.

The main shunt field, commutating field and compensating field windings are carried on laminated poles bolted to the heavy ribbed section magnet frame. The space between the two magnet frames is enclosed by a sheet steel casing, into which the cooling air is introduced under pressure, which forces it through the armature windings and field coils and out through the commutator ends of the machine. The air, before being taken into the motor, is thoroughly washed and scrubbed and, being discharged into the motor room, tends to build up a slight posi-

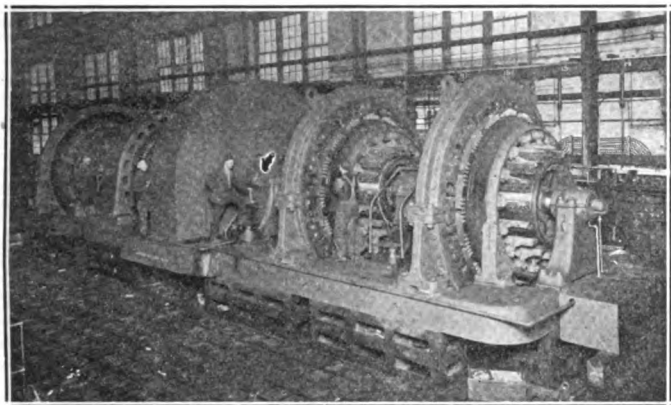


Fig. 1—7,000 hp reversing blooming mill motor consisting of 2 type MCF 22-3,500 hp (50°) 55/120-900 volt units.

tive pressure which retards the entrance of mill dirt into the room.

The power for driving the reversing mill is obtained from a 4 unit flywheel motor generator, consisting of three 2,700 kw 600 V shunt wound generators. The generator and motor armatures are connected alternately in series through a high capacity solenoid operated air break circuit breaker. Excitation for the shunt fields of the generators and motor is furnished by an induction motor driven exciter.

A slip regulator, connected in the secondary of the induction motor driving the flywheel motor generator, automatically introduces resistance into the secondary circuit, whenever the induction motor load exceeds a pre-determined value, thus causing the induction motor to slow down and allowing the flywheel to carry the load in excess of the regulator setting. Conversely, when the load on the induction motor tends to drop below the regulator setting, resistance is taken out of the secondary circuit and the induction motor input remains practically constant until the flywheel has returned to its maximum speed. In this way, the peaks which are very severe in the dc circuit, are practically eliminated from the ac supply.

Control of the speed and direction of rotation of the main motor is obtained from the single lever master switch in the operator's pulpit. For speeds from 55 rpm forward to 55 rpm reversed, the motor field remains constant at its maximum value, and control is obtained by varying the direction and value of current in the shunt field circuit of the generator. For speeds from 55 rpm to 120 rpm which is the maximum for this particular equipment, control is obtained by varying the motor shunt field current. The control apparatus includes protective devices which prevent abusive handling of the equipment without interfering in the least with the operator as long as the armature currents are not excessive, and as soon as the current drops to a safe value, complete control is returned to the operator.

The following figures which have been obtained under actual rolling conditions on similar equipments are of interest:

The General Electric equipment at the Trumbull Steel Company, driving their 36-inch reversing blooming mill, has rolled one 22 x 60-inch ingot weighing 6,700 pounds down to a 6¾ x 6¾-inch bloom in 11 passes in 45 seconds. Fifty-seven such ingots, having a total weight of 190 short tons, have been rolled to the same final dimensions in one hour.

The 40-inch reversing mill at the Sparrow's Point works of the Bethlehem Steel Company is driven by an electrical equipment very similar to that at the Trumbull Steel Company. This mill has rolled one 23 x 43-inch ingot weighing 16,500 pounds to a slab 9 x 38-inch in 1 minute and 20 seconds, and to a bloom 8 x 8-inch in 2 minutes and 15 seconds. This mill has also rolled 330 tons of 10 x 40-inch slabs in one hour, and 198 tons of 8 x 8-inch blooms in an hour.

These figures tend to show that the modern electrically driven reversing mill is at least on par with the steam driven mill as far as tonnage output is concerned, and when its many advantages, such as economy of power and maintenance, costs, and flexibility and ease of control are considered, the superiority of the electric mill is obvious.

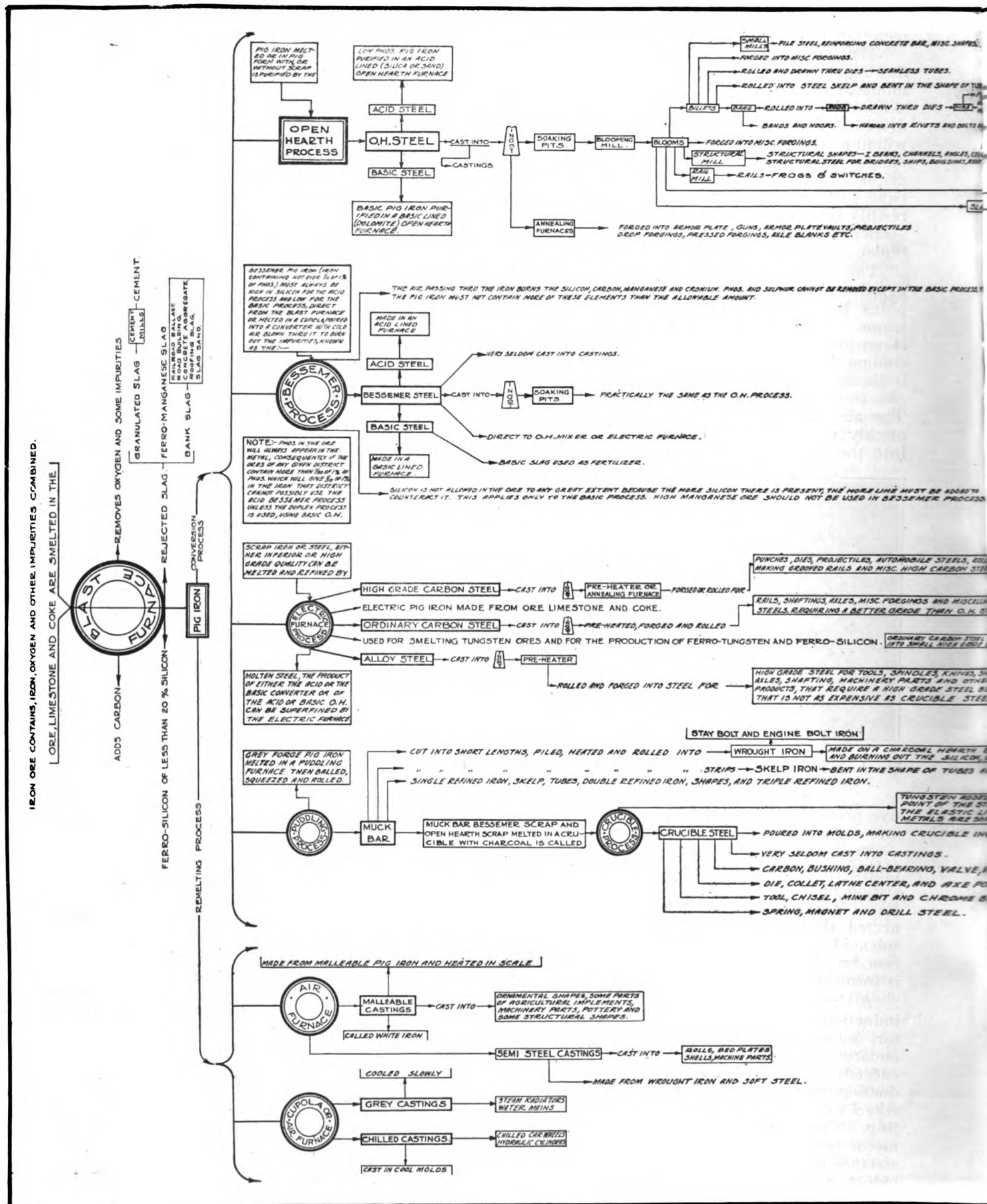
CONVENTION OF AMERICAN DROP FORGE AND DROP FORGE SUPPLY ASSOCIATION.

The annual joint convention of the American Drop Forge Association and the Drop Forge Supply Association will be held this year in Chicago, June 22-23-24. The following joint committee in charge of entertainment and general arrangements for the convention has been appointed:

For the American Drop Forge Association: Samuel M. Havens, chairman, Ingalls-Shepard Forging Company, Harvey, Ill.; W. E. Crocombe, Ajax Forge Company, Chicago, Ill.; Thos. P. Octigan, Octigan Drop Forge Company, Chicago, Ill.

For the Drop Forge Supply Association: C. H. Hallgath, chairman, Western Sales Manager, N. & G. Taylor Co., 208 S. LaSalle street, Chicago, Ill.; A. L. Guilford, Manager Chicago Office, Ajax Manufacturing Company, Chicago, Ill.; R. S. LeBarre, General Sales Manager, Alloy Division, Interstate Iron & Steel Co., Chicago, Ill.

The largest attendance in the history of the industry is expected at this convention and plans are now being considered by the committee and the officers of both associations to make this meeting surpass all others in interest and enjoyment.





On The Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

By DR. ING. KARL GRUBER IN RHEYDT.

PART III

6. *Interdependence of Formation of Hollow and Torsional Angle.* We now propose to deal with the conditions which develop when the front end of the ingot is inserted into the rolls. The clearance of the rolls is to be such that the solid ingot of 160 mm diameter is rolled down gradually to the small diameter of 136 mm, i.e., down to $1.85 d_0$. On the further assumption that the inclination of the side of the working taper of the rolls amounts to 1:15, a length of ingot taper of 180 mm is obtained which is to be divided up in six equal parts (Fig. 14). Now we determine for each of the sections 1 to 6 the torsional angle in degrees according to equation No. 8, using the figures given in Fig. 14 for this purpose.

$$\delta = \frac{D \times \frac{d_0 - d_1}{a_1} - D_0 \times \frac{d_0 - d_1}{d_0}}{D + D_0} \times \frac{360}{\pi \tan \beta \tan \delta}$$

With $\beta = 5^\circ$ and $\tan \delta = 1/15$, the second element becomes

$$\frac{360}{\pi \times 0.0875 \times 1/15} = \frac{360}{0.01833} = 19,640.$$

Now for the first cross section we obtain:

$$\delta_1 = \frac{340 \times 4/156 - 336 \times 4/160}{340 + 336} \times 19,640$$

$$\delta_1 = \frac{0.318}{676} \times 19,640 = 9.24^\circ$$

Similarly, for the other cross sections the following is obtained:

$$\delta_2 = \frac{344 \times 8/152 - 336 \times 8/160}{344 + 336} \times 19,640 = 37.54^\circ$$

$$\delta_3 = \frac{348 \times 12/148 - 336 \times 12/160}{348 + 336} \times 19,640 = 86.14^\circ$$

$$\delta_4 = \frac{352 \times 16/144 - 336 \times 16/160}{352 + 336} \times 19,400 = 157.00^\circ$$

$$\delta_5 = \frac{356 \times 20/140 - 336 \times 20/160}{356 + 336} \times 19,640 = 157.00^\circ$$

$$\delta_6 = \frac{360 \times 24/136 - 336 \times 24/160}{360 + 336} \times 19,640 = 370.50^\circ$$

The torsional angles have been plotted in Fig. 15 as ordinates and the resulting curve shows in which rapid way they are growing. From this it may be taken that the formation of the hollow proceeds at a rapid rate as well.

At the beginning, from zero up to 1, the curve is rising but very hesitatingly and at the point 1 probably only the beginning of hollowing action would be noticeable.

The formation of a hollow by a torsioning of the whole cross section is hardly feasible, more especially so as the forces at disposal would not suffice for the purpose. It

*Stahl & Eisen, July 1882, page 283-93; February 1883, page 121-22.

appears to be correct, however, that a torsioning of the material on the outside surface takes place, as per calculation, and that the particles of the material in the interior follow the outer ones in this movement causing the inner material to be drawn to the surface, owing to its cohesive properties.

Using this theory for oblique rolling process and considering the various cross sections 0 to 6 after having determined the various torsional angles of the outside fiber, the formation of the hollow can be explained in the way shown in Fig. 17.

At cross section 0 the ingot has just been gripped by the rolls and the radial rods are straight. At cross section 1 a torsioning of the outside fiber $\delta_1 = 9^\circ 24''$ has already taken place and the radial rod is bent accordingly, so that a hollow must gradually form in the interior since a stretching of the radial rod cannot be assumed. This torsioning is accompanied by a shifting of the fiber in a longitudinal direction causing each radial rod not only to be bent in the plane of the cross section but to be spirally rotated from out of this plane. The radial rods follow the outer circumference in increasing degree when the action proceeds from cross sections 3 to 6, respectively, in accordance with the increase of the torsional angle. It is unfortunate that experiments cannot be carried out at the present time in order to obtain definite information on the fiber formation; they could be carried through in a way similar to that mentioned in discussing the standard rolling process. Still, there is not much room for doubting that the hollowing of the material is to be explained in the way shown.

The next Fig. 18 shows a radial rod while passing through the cross sections 1 to 6. It will be noticed that the inner ends of the radial rod form a spiral.

If now the torsional angles at the various cross sections are coördinated to the corresponding radii of the hollow, it is possible, for working out the inside width d_1 when the outside diameter equals d_a , to set up the empirical formula:

$$d_1 = \frac{d_a}{100} \sqrt{\delta + 0.05 \delta^2} \quad (18)$$

Table 2 has been worked out by using this formula, as well as Fig. 18.

Table 2—Torsional Angle When Inserting the Ingot.

Cross Section No.	Torsional Angle Deg.	d_a/d_1	d_a mm	d_1 mm
1	9.24	0.037	156	5.8
2	37.54	0.104	152	15.8
3	86.14	0.214	148	31.7
4	157.00	0.372	144	53.6
5	251.46	0.584	140	81.8
6	370.50	0.85	136	116

In drawing Fig. 14 the values of the above table have been made use of, and the inside shape of the hollow shown may be taken as a faithful reproduction of what

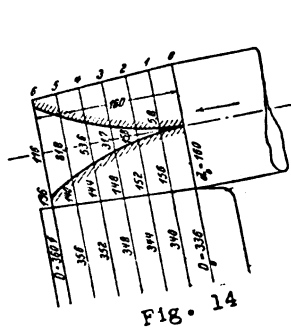


Fig. 14

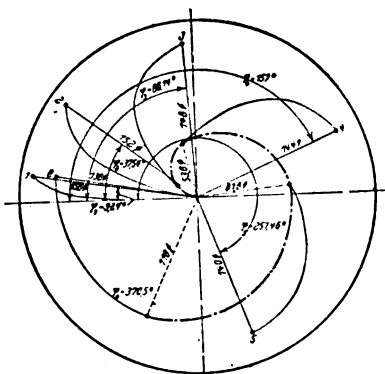


Fig. 18- Hollow between sections 1 to 6.

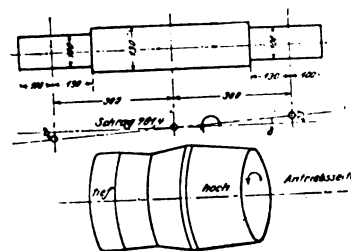


Fig. 30- Top Roll for 360 Mm. Mill.

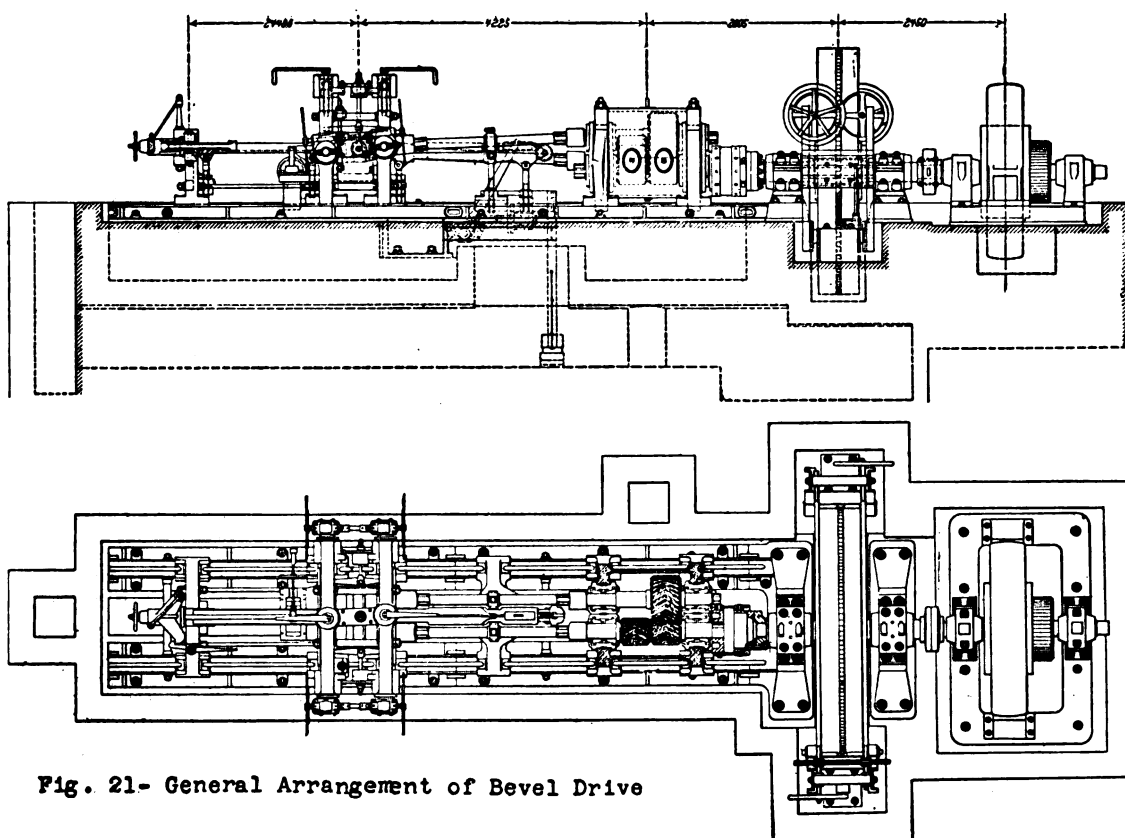


Fig. 21- General Arrangement of Bevel Drive

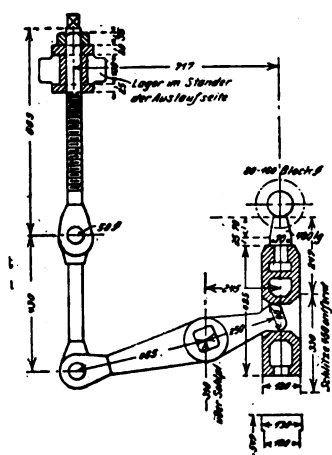


Fig. 25- Lower Grooves between Rolls.

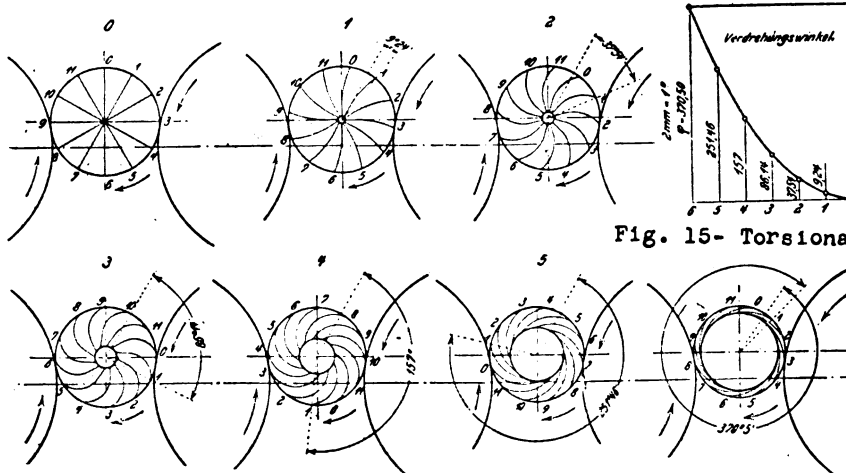


Fig. 17- Formation of Hollow in Mill.

Fig. 15- Torsional Angle

it actually looks like. In this connection special attention should be drawn to the fact that the Stiefel rolling mill, dealt with later on, which is used for making thin walled copper tubes is using torsional angles δ of about 300 degrees. It may therefore be taken that the small thickness of wall obtained in our calculations for 370.5 degrees is not very far from the truth.

In the case of iron tubes, however, the greater thicknesses of wall have to be considered. For instance: If the solid ingot of 160 mm diameter is to be rolled into a hollow bloom with a $d_a = 160$ mm and a $d_i = 110$ mm with an annular cross section of 10,600 sq mm, then this cross section has to be provided at the ingot taper. This happens to be the case very closely at cross section No. 5 (Fig. 14). The rolls have to be adjusted in such a way that the diameter is reduced from 160 to 140 mm.

As soon as the end of the ingot, i.e. cross section No. 6 has reached the rolls, the last phase of the rolling process begins. *The hollow obtained thus far is retained and the smaller inner diameters have now to be forced over the mandrel. The feeding movement is retarded considerably, and the power required which up to the present had been relatively small, increases very appreciably.*

The heavy increase of power forms one of the disadvantages of the oblique rolling mill.

The brothers Mannesmann in the course of their experiments experienced considerable difficulties through this rise in the power requirements towards the end of the rolling process. It had been ascertained that for producing 1 inch or 2 inch tubes, about 1700 or 2000 hp were necessary which, through using a large, high speed flywheel which was wire bound, could be provided. The power required became much less, as soon as the attempt to obtain thin walled iron tubes was dropped and the oblique rolling process was used for the clogging mill only. There is, however, in spite of this a very large increase in the power required towards the end of the rolling process as the hollow is but imperfectly produced so that the material has to be forced over the mandrel.

It was noticed that the power required increased very rapidly towards the end and it therefore appears to be advisable to provide and utilize as heavy flywheels as possible in order to obtain a more evened up load. In the case of electric drive, compound wound motors are used which are capable of carrying a momentary overload of 150 per cent. The rolling process proper takes only about 20 seconds and the additional 16 seconds are required in order to speed up the flywheel to its usual speed which has fallen off owing to the output of power. In order to reduce ingots of up to 160 mm diameter at the big end to a thickness of wall of from about 25 to 30 mm a compound wound motor developing 360 hp, and of the overload capacity stated in conjunction with a 30 ton flywheel running at 150 rpm will be sufficient. Motor and flywheel drop after 20 seconds from 150 to 128 rpm, but after another 16 seconds the original speed has been recovered, provided the voltage can be kept approximately constant during the rolling period.

At present the large rolling mills are fitted with 2000 hp motors and a 40 to 50 ton flywheel while the speed amounts to 100 rpm.

7. *Design of the Rolling Mill*—The bevel drive which was used in the early designs and which is shown in the paper of Prof. Reuleaux caused difficulties and was abandoned later on. The designers of the Mannesmann works have succeeded in developing a design which is still used everywhere. The arrangement is shown in

Fig. 21. The main shaft drives a spindle housing which through gearing sets the working rolls into motion, by means of long coupling shafts. This arrangement allows more, especially by using the long coupling shafts, to provide a guide through between the latter which is used for inserting the ingot into the rolls. The wobblers which also during the first few years caused considerable difficulties are now designed on the same lines as in standard rolling mills.

The roll housings are supported by standard bottom plates. Horizontal guides are provided for the bearings of the rolls containing liners with ball shape bearing surfaces through which any required adjustment of the rolls at the front as well as at the rear end becomes possible. The top roll guide, arranged on top in the center, has also a liner provided. The bearings of the three rolls mentioned above are adjustable and by means of springs the liners are pressed against the adjusting screw thus insuring good contact in the bearings. The sliding bar below the top roll moves in a guide.

The leading-in trough has a vertical adjustment of 70 mm and takes billets of from 80 to 160 mm diameter. The billet is moved in the trough by 1,140 mm by means of a ram. If a load of 200 kg including weight of ram has to be shifted in the trough and a counterweight of 110 kg must be lifted the requisite water pressure in the hydraulic cylinder will be 17 to 18 *at*. As the working pressure amounts to from 50 to 100 *at* the billet can therefore be forced into the rolls until the latter have gripped it. The lever must move in the centre slot of the guide because the bearings of the coupling spindles extend to within so short a distance of the guide that the latter cannot be encircled. The coupling spindles are 3,000 mm long and are supported in the middle by bearings of 150 mm diameter, 140 mm long.

In the larger 550 mm rolling mill the coupling spindles are 3,620 mm long and have a diameter of 250 mm. The bearings of the coupling spindles and the supports of the guide troughs are arranged symmetrically at a distance of 2,300 mm from the coupling spindle ends. The two housings thus take the screwed guide spindles, the supports of the bearings and the hydraulic cylinder. The fulcrum of the push-in lever which latter may now move freely and can have a forked top end is supported by a bridge between the two housings.

When the thickness of the block increases from 140 to 450 mm, the guide trough has to be lowered by 220 mm. In the case of tapering ingots the guide trough must be adjusted to an angle so that the orientation of the ingot centre line is perfectly horizontal and falls between the rolls. The largest ingot has a diameter of 450 to 430 mm, a length of 1,200 mm and a weight of 1,400 kg; the weight of the ram which can be extended in this design is 148 kg. The frictional resistance of the two is thus about 150 kg. To this the counterweight of 160 kg has to be added. The force at the point where the plunger acts becomes therefore: $4.3 (500 + 160) = 2,840$ kg. To overcome this a water pressure of 23 *at* has to be used, with a plunger of 140 mm diameter. As the usual water pressure is 50 to 100 *at*, it is seen that there is plenty of margin to effect the pressing-in.

The ram is hollow and takes the extension which is fixed by means of feather or screw. After this has been arranged for, an ingot of 1,000 mm length can be pushed into the rolls.

The oblique position of the coupling spindles (see Fig. 24) in relation to the centre lines of the pinions is found as:

$$\tan \beta_1 = \frac{291^2 + 140^2}{3620} = \frac{323}{3620} = \frac{1}{11.2}$$

The coupling bushes on the rolls will not be much included; on the pinions the inclination is more marked.

Fig. 25 shows an arrangement for guiding the ingot in a rolling mill of 360 mm diameter of rolls. The guide carriage is made of cast iron, has a guide bar and travels between the two roll housings being made to fit closely. A square shaft of 75 mm thickness is supported by two bearings of 75 mm diameter arranged in the housings. To the square shaft two levers are fixed at a distance of 450 mm between centre lines, one being a double armed and the other a short, single armed one. The carriage can only be lowered 40 mm.

In the 550-mm rolling mill the guide carriage is raised and lowered by means of two screws in conjunction with the two worm wheels and a worm which is arranged in the centre. The adjustable hub is mounted on the shaft, outside of the roll housing, and has 6 radially disposed holes for inserting the lever rod.

As the ingot is passed through the rolls in a plane

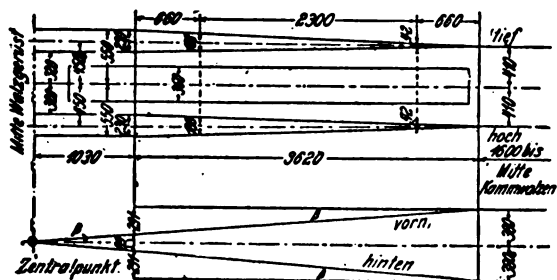


Fig. 24

which, in the smaller rolling mill is 40 mm and in the larger one 50 mm higher than the centre plane, this bottom guide is of no great importance and acts as a safety device only.

While the rolling process goes on the hollow bloom revolves on the mandrel the latter being supported at one end by the mandrel thrust bearing and at the other by the hollow bloom itself. After the rolling process is finished, the hollow bloom as well as the mandrel drop on to the discharge trough from which the former can be withdrawn after the mandrel thrust bearing has been opened. In the large rolling mills the guides for the blooms have rollers provided and are also adjustable in a vertical direction.

At the start of the rolling process, the mandrel rests on one end, at the thrust bearing only, and its front end has to be supported until it is gripped by the hollow bloom. This support is supplied by the centering device for the mandrel shown in Fig. 28, which by means of a foot lever keeps the mandrel in the proper position until it has entered into the hollow of the bloom. As soon as the mandrel rod has thus assumed a fixed position, the centering device is disengaged.

A mandrel thrust bearing for a 360-mm rolling mill consists in the main of a swivel bearing which can be clamped in the closed position through a stirrup. This swivel bearing contains a roller thrust

bearing for the pinion shaft. The latter has in its front part a die plate with a square recessed opening for the support of the mandrel. When the mandrel rotates, the pinion shaft rotates as well and during rolling runs in the collar thrust bearing. The resistance of the mandrel in the rolling mill is reduced when the mandrel is able to rotate.

The collar thrust bearing can be shifted lengthwise by means of an adjusting screw in order to set the mandrel properly.

The method of operation at the mandrel thrust bearing is as follows:

The mandrel is taken from the trough and after the bearing has been closed is inserted into the die plate. Then by means of the hand wheel the collar thrust bearing is fed forward until the mandrel has assumed the proper position. On the rolling process being finished, the hollow bloom which rests on the mandrel can be removed after the stirrup has been opened. If now a new mandrel of equal length is

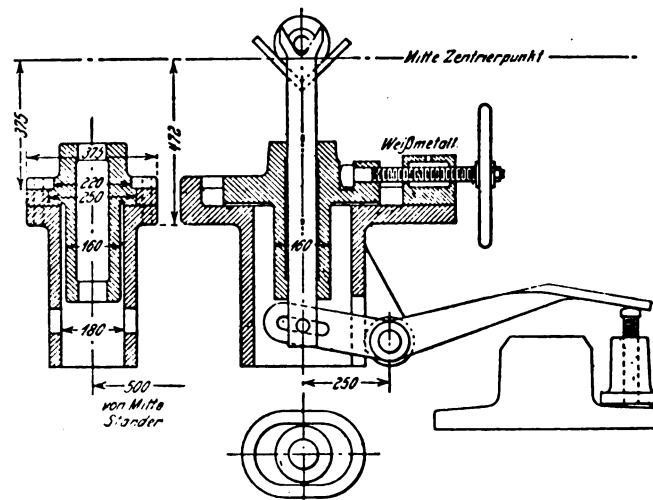


Fig. 28

inserted, the mandrel thrust bearing can again be closed when the centering device for the mandrel will hold the latter up, between the centres of the rolls, until the mandrel has entered a new hollow bloom.

The mandrel thrust bearings of the 550-mm rolling mills have a hydraulic device for adjusting the collar thrust bearing.

The top roll is arranged over the two side rolls and in this way the top part of the pass is closed (see Fig. 6). The strain on the top roll amounts to 1/3 of the rolling pressure between the main rolls. The direction of rotation is the same as that of the main rolls. The top roll (Fig. 30) is arranged obliquely in a horizontal plane which is disposed 145 to 185 mm over the center point of the rolling mill in such a way that the movement of its circumference is adapted to the helical movement of the hollow bloom.

$$\tan \delta_1 = 23 : 380 = 0.0606 \text{ or } \delta_1 = 3.5^\circ$$

Experience has shown that s_x can be reduced to about one-half owing to the friction between rolls and specimen and the resistance of the mandrel, and $\delta = 3.5^\circ$ is therefore a suitable value for the degree of obliquity of the top roll. At the same time the degree of obliquity of the top roll as compared with that of the main rolls is so adjusted that the proper clearance between the rolls as well as that in the bearings is obtained.

(To be continued in June Issue)

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

By ALFRED STANSFIELD, D.Sc., A.R.S.M., F.R.S.C.,
Birks Professor of Metallurgy at McGill University.

PART III

IN this type of furnace each arc is maintained between one electrode and the material to be melted, and the arcs are operated in series of two. The electrical connections of furnaces of this class are shown diagrammatically in Fig. 12. Each electric current that is employed enters the furnace by one electrode, passes through an arc, then through the contents of the furnace, then through another arc and finally leaves the furnace by a second electrode. Compared with the Independent Arc Furnaces it will be seen that the material to be melted is heated more rapidly because it forms one pole of each electric arc, and also, to some extent, because it forms the path of the electric current between the two arcs of each series. On the other hand this type of furnace cannot be operated empty, as some conducting material is

Heroult Furnace.

The furnace patented by the late Paul Heroult in 1900, has become the most widely used electric furnace for melting and refining steel. While there are many differences in construction between different varieties of this furnace, the points that are common to all may be summarized as follows:

1. The Heroult furnace resembles an open hearth furnace in general construction except that there are no gas or air ports or regenerative chambers and that the heating is effected by means of electric arcs. The furnace may be stationary but is usually made tilting so as to pour the molten steel and for the removal of slag.

2. The electric current is led into and out of the furnace by vertical electrodes of carbon or graphite which pass through the roof of the furnaces. Short electric arcs are maintained between the lower ends of these electrodes and the contents of the furnace.

3. No electrical connection is made to the hearth of the furnace and in consequence the arcs are operated electrically in series of two; that is to say, each electric circuit contains two arcs.

4. The furnace may be supplied with single-phase current, in which case it would have two electrodes, but the great majority use three-phase current and have three electrodes. Furnaces have been designed with four electrodes using two-phase current, and with six electrodes using three-phase current, but no furnaces have been built with more than three electrodes.

5. Electric power is supplied to the furnace at about one hundred volts, being stepped down to this voltage by single-phase or poly-phase service transformers. The transformers should have a moderate amount of inductive regulation in order to control to some extent the violent surgings of current during the melting period.

6. The supply of power to the furnace is controlled by raising and lowering the electrodes. In a single-phase furnace it is necessary to observe the voltage between each electrode and the furnace hearth in order that the power may be divided equally between the two arcs, but in a three-phase furnace the ammeter reading can be used for the regulation of each electrode. The electrodes can be regulated by hand but automatic regulators are generally employed.

7. The electrodes are supported by mechanism attached to the furnace shell so that the furnace can be tilted without affecting the height of the electrodes above the charge.

The construction of the Heroult furnace can be seen from the following illustration:

In Fig. 13 is shown the construction of a Heroult furnace of small size such as would be suitable for a

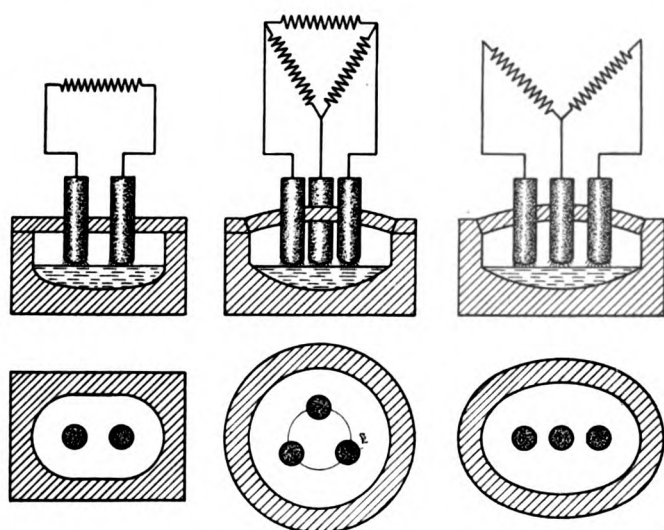


Fig. 12—Heroult Single-phase.
Vom Baur Two-phase.

Heroult Three-phase.
Ludlum Three-phase.

needed to carry the current. The series feature also causes a certain difficulty in starting the arcs, because both of the electrodes concerned must make contact with the charge before either of the two arcs can be started, and the failure of the one arc, in a single-phase furnace, serves to extinguish the other arc of the pair.

The outstanding example of this type is the Heroult furnace which is built in single-phase and three-phase varieties, but the Ludlum furnace, using three-phase current and the Vom Baur furnace, using two-phase current, are also in the series-arc class.

*From a paper by J. H. Gray, "The Electric Furnace in the Foundry." See reference 7.

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steel foundry. It consists of a circular steel box lined with refractory materials and having three electrodes which enter through the dome-shaped roof. The furnace rests upon a steel platform which hinges about an axis passing just under the spout, so that in pouring, the spout remains nearly stationary. The tilting mechanism is electrically operated and lifts the furnace by means of connecting rods attached to a large gear wheel; a heavy counterweight being provided to balance the weight of the furnace. On starting the tilting machinery the furnace rises until it assumes the position shown by the dotted lines. Further motion of the machinery, in the same direction, will bring the furnace back again to its normal position.

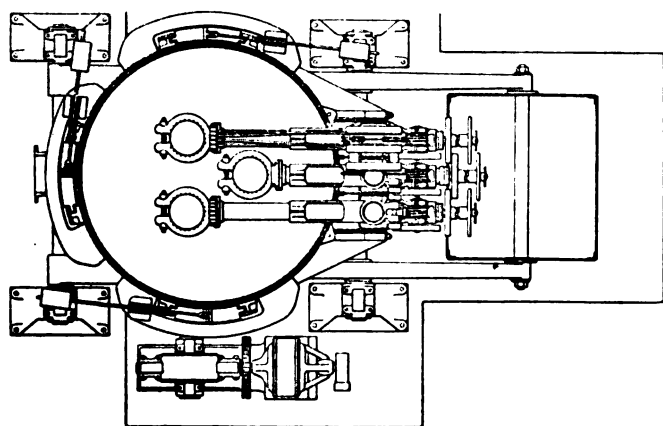
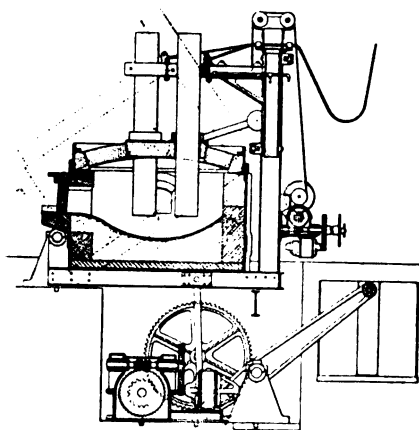


Fig. 13—Heroult furnace of three tons capacity.

There is therefore no danger of accident through forgetting to stop the motor.

In the case of larger furnaces it is usually less important to keep the spout stationary, and in order to lessen the work of tilting, the hinging axis is placed underneath the furnace, instead of at the spout, or the furnace may be placed on rockers like a tilting open hearth furnace, as shown in Fig. 14.

The electrodes are supported by a vertical steel mast or standard attached rigidly to the base of the furnace, so that the electrodes and their holders tilt with the furnace. For each electrode there is a carriage that rides up and down the mast, being operated by a steel rope from an electric motor near the base. Each carriage supports a jib arm, extending towards

the electrode, and attached to this, but insulated from it is a water-cooled holder which supports the electrode and supplies the electric current. Insulated copper conductors lead from the electrode holder, above the top of the carriage, to the flexible cables that connect to the low tension bus-bars; these cables being long enough to permit the tilting of the furnace.

The furnace itself consists of a circular steel box, having two charging doors and a spout, which is also closed by a door. The roof is a domed arch of silica brick, usually nine inches thick, and built in a circular steel ring so that the whole roof can be lifted off the furnace, when worn out, and can be replaced by a new one. The upper walls of the furnace, which are 14 or 18 inches thick, are also built of silica brick, while the lower part of the walls and the hearth may be either acid or basic. An acid or silica-lined furnace is lined with silica bricks throughout; the brickwork is brought nearly to the desired shape of the hearth and is then covered with silica sand which becomes fritted together and form the working hearth. A basic furnace has magnesite bricks for the lower walls and over the bottom plate, and a thick bottom of burnt magnesite is built up to the desired form as shown in Fig. 13.

This basic hearth-lining consists of strongly calcined grain magnesite to which from 10 to 20 per cent of open hearth slag has been added for the purpose of forming a permanent bond when the hearth is heated. One method of making the hearth is to mix the magnesite and slag with hot tar or pitch so as to make a plastic mass, and to ram this into the furnace to the required depth with hot rammers. A bed of coke is then laid on this hearth to form an electrical contact, the electrodes are lowered, and the hearth is gradually heated to drive out the volatile matters, thus leaving a coked mass; ultimately the slag in the upper layers fuses, and thus a compact hearth is formed. By this process, however, it is not possible to sinter the hearth as far down as the brick work, and a more satisfactory way is to add the burnt magnesite and open hearth slag in thin layers; heating each layer to the sintering point before adding the next layer. For this purpose the use of coke, as a conductor, is inconvenient as it would have to be completely removed before the next layer of magnesite could be added, and the method adopted is to use an "electrode star" supported on piers of magnesite brick, for the purpose of completing the electric circuit between the electrodes (12).† When the hearth is thoroughly heated, it becomes an electrical conductor and the arcs can be maintained between the electrodes and the hearth itself, thus permitting additional magnesite to be introduced and sintered into place until the hearth is built up to the desired thickness.

The electrodes are circular rods of amorphous carbon or of graphite, the former varying from about 8 inches to 24 inches in diameter. These electrodes are made in lengths of about five feet which are connected end to end by threaded joints, using molded carbon nipples. As each electrode burns away in the furnace it is gradually lowered until the jib arm gets too near the roof of the furnace; a new length of electrode is then added and the holder is raised and slackened so as to allow the electrode to slide through it for a suitable distance. The holes in the furnace roof cannot be made to fit the electrodes closely, but

†See references at end of this section.

a water-cooled collar, which rests on the roof, fits around the electrode and prevents any considerable escape of flame or hot gases from the furnace. This collar also serves to keep cool the portion of the electrode that is above the arch. That part of the electrode within the furnace wears away on account of volatilization of carbon from the strongly heated tip from which the arc passes. Apart from this the electrode wears to some extent by oxidation as a result of air finding its way into the furnace, and on this account great care should be taken to keep the door

heating of the walls; the circle passing through the electrode-centres has a radius of 21 inches, which is about three-sevenths of the inner radius of the furnace wall, which is 48 inches. The electrode support consists of two parts: the upper arm is attached to the carriage which moves up and down in the mast, while the lower arm which consists of a copper conductor and water-cooled electrode-clamp is supported by, but insulated from the upper arm. The machinery for tilting the furnace is not shown, it would be similar to that in Fig. 13.

The Heroult furnace is built in one, two, three, six and ten gross-ton sizes for melting cold scrap, and of 30 tons capacity for refining molten steel. The following table (7) shows the electrical power per ton, the transformer capacity and the corresponding current in amperes carried by each electrode:

Table 7.

Size of Furnace Tons	Power per ton, kva.	Transformer Capacity, kva.	Amperes for each electrode
1	500	500	3,000
2	400	800	4,800
3	330	1,000	6,000
4	300	1,200	7,500
6	250	1,500	9,000
10	225	2,250	13,500
15	200	3,000	18,000
25	150	3,750	21,500

The electrical power per ton of furnace capacity has been increased, during recent years, with a view of obtaining a better efficiency during the melting period, though decidedly less power can be used during the refining period on account of the danger of melting the walls and roof. The power per ton of steel in the furnace decreases as the furnace becomes larger because the loss of heat per ton is less in the larger sizes. The 25-ton furnace, which holds 30 tons of steel and is used for refining molten steel and not for melting steel scrap, only needs from 100 to 150 kva per ton.

The electric current, in amperes, supplied to each electrode is obtained from the kva supplied to the

furnace by the formula: $kva = \frac{\sqrt{3} VA}{1000}$ where A

is the number of amperes per electrode and V is the voltage between any two electrodes. If V is taken as 100 volts we find that A is 5.8 x kva, and in the table the ratio 6 has been used.

The electrodes are usually made of amorphous carbon, but graphitized electrodes are sometimes used. The sizes of these electrodes could be calculated from Carl Hering's data,* but in general they are made somewhat stouter than is indicated by these considerations. Table No. 8 shows the sizes that

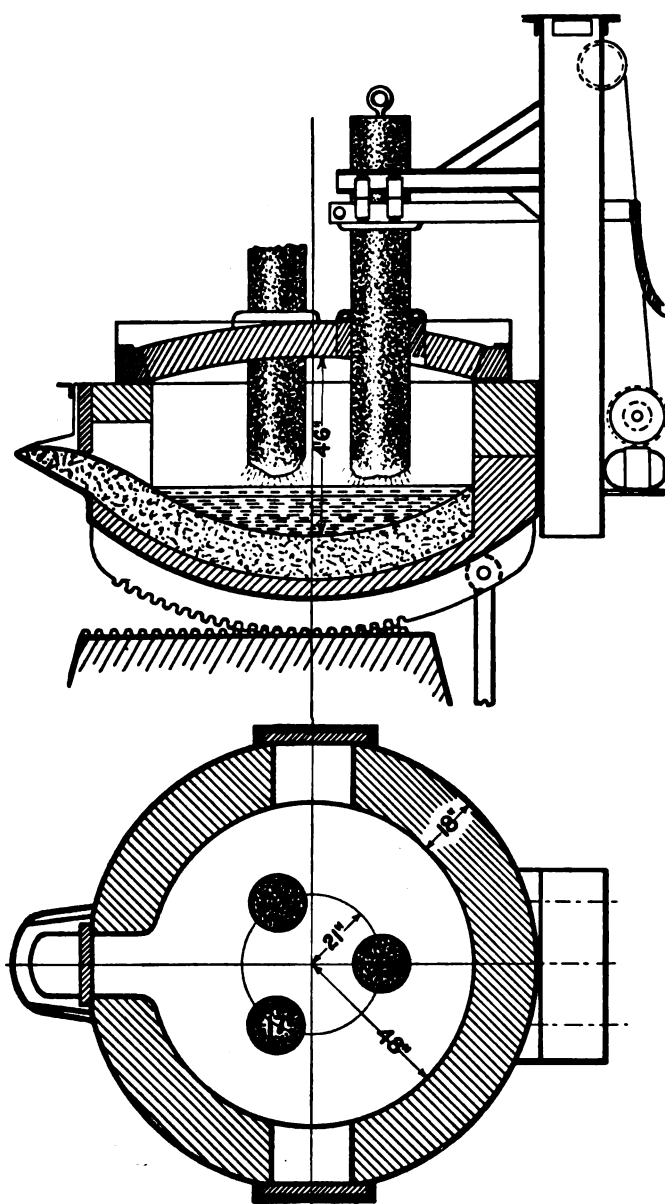


Fig. 14—Six-ton Heroult furnace.

as tightly closed as possible. Above the arch of the furnace the electrode should be too cool to burn and this part of the electrode should be kept as short as practicable since its length increases the loss of electrical energy.

Figure 14 is a sectional plan and elevation of a 6-ton Heroult furnace drawn approximately to scale and showing the principal dimensions. The hearth is basic, consisting of magnesite brick and a lining of crushed magnesite. The electrodes are grouped somewhat closely as is necessary to avoid local over-

Table 8.

Sizes of Electrodes for Heroult Furnaces.

Size of Furnace Tons	Amperes per Electrode	Carbon Electrodes		Graphite Electrodes	
		Size of Electrode inches	Amperes per sq. inch	Size of Electrode inches	Amperes per sq. inch
1	3,000	8	60	4	240
2	4,800	12	42	6	168
3	6,000	14	39	7	156
4	7,500	14	49	7	196
6	9,000	17	40	8	160
10	13,500	20	43	10	172
15	18,000	24	40	12	160
25	21,500	..	..	..	..

*Stansfield, The Electric Furnace, pages 98-108.

are used in practice and the resulting current density. The consumption of carbon electrodes varies from about 30 to 35 pounds per ton when melting scrap steel, and from 8 to 12 pounds when refining molten metal.

The electric current is carried from the transformers to the furnace by means of copper bus-bars which are interlaced so as to keep a high power-factor. Bare flexible cables must be used at one point to enable the furnace to tilt. The bus-bars may be made to carry 800 to 1000 amperes per square inch of cross-section and the flexible cables can carry 800 to 1000 amperes per 1,000,000 circular mils, as shown in the following table:

Size of Copper Conductors for Each Electrode of Heroult Furnace.

Size of Furnace Tons	Amperes per Electrode	—Bus-bars—		—Flexible cables—
		Square inches Section	No. and width of ¼-inch bars	No. and size
1	3,000	3	2 of 6-inch	4 of 750,000 cm.
2	4,800	5	4 of 5-inch	6 of 800,000 cm.
3	6,000	6	4 of 6-inch	6 of 1,000,000 cm.
4	7,500	7	4 of 7-inch	8 of 1,000,000 cm.
6	9,000	9	6 of 6-inch	6 of 2,000,000 cm.
10	13,500	16	8 of 8-inch	8 of 2,000,000 cm.
15	18,000	24	12 of 8-inch	12 of 2,000,000 cm.
25	21,500			

Heroult furnaces are used for melting cold scrap for the production of steel castings, high-speed tool-steel, various special tool-steels and alloy-steels. They are also used to some extent for melting iron for gray iron and malleable iron castings. The larger sizes are used for refining molten steel that has been made in the Bessemer converter or the open hearth furnace.

The power consumption for refining molten steel will vary from 100 to 200 kw-hours per ton, while for melting cold scrap some 600 to 900 kw-hours will be needed. The yearly load-factor of an electric furnace, on continuous operation, will range from 45 to 50 per cent, while the daily load-factor will be between 50 and 55 per cent.

The following is a summarized list of Heroult furnaces building and operating in the United States and Canada and licensed by the U. S. Steel Corporation on the first of September, 1919.*

Heroult Furnaces in United States and Canada.

Size of Furnace	Number	Products
¼ ton	1	Cast Steel
1 ton	8	Castings and Ingots
2 ton	25	Castings and Ingots
3 ton	24	Castings and Ingots
4 ton	2	Ingots and molten ferro-manganese
5 ton	1	Ingots
6 ton	75	Castings, ingots and pig iron
10 tons	2	Ingots
15 tons	7	Castings and ingots
25 tons	4	Ingots
40 tons	2	Ingots

The 25-ton Heroult furnace has been used for making steel by the triplex process at South Chicago; molten pig iron being blown in Bessemer converters, then transferred to open hearth furnaces for the removal of phosphorous, and after that to electric furnaces for removing the oxides, sulphur and gases.

*The author wishes to express his indebtedness to Mr. J. H. Gray and Mr. R. L. Baldwin of the U. S. Steel Corporation for information with regard to the construction and operation of Heroult furnaces.

ASSOCIATION OF IRON & STEEL ELECTRICAL ENGINEERS.

The Association of Iron & Steel Electrical Engineers will hold its 15th annual convention during the week of September 19 to 24, 1921, at the LaSalle Hotel, Chicago, Illinois.

The two most important features of this convention will be:

First—The educational feature which will comprise exhibits of the various electrical manufacturers of the United States. In 1919 this plan was tried out with success. In 1920 while the exhibition was tripled with regard to space, it still was not sufficient to gratify the demands of the electrical manufacturers. The increase in the interest of the exhibitors in 1920 over that of 1919 was caused by the enthusiasm displayed by the active members of our association (electrical, mechanical and combustion engineers in the steel mills). It is the intention of the association this year to make the educational feature just what such an exhibit should be, namely, acquainting the steel mill engineers with the latest developments in steel mill apparatus. In fact, the steel mill engineers feel that this is the only opportunity presented to them whereby they can secure first hand knowledge of the products necessary for successful operation in the steel mills.

Second—The technical sessions which will consist of morning and afternoon meetings devoted to papers of engineering interest to the steel mill engineers. The steel mill authors will be: R. B. Gerhardt, electrical superintendent, Bethlehem Steel Company, Sparrows Point, Md.; R. W. Cousins, electrical engineer, Illinois Steel Company, Gary, Ind.; Wray Dudley, electrical superintendent, Ashland Iron & Mining Co., Ashland, Ky.; W. N. Flanagan, steam engineer, Ohio Works, Carnegie Steel Company, Youngstown, O.; F. E. Leahy, fuel and expert engineer, Carnegie Steel Company, Duquesne, Pa.; G. R. McDermott, assistant chief engineer, Illinois Steel Company, South Chicago, Ill.

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A New Balanced Sheet Mill Drive

Josef Hirschmann, Chief Engineer of the Eastern Rolling Mill Company, Designs a New Drive Which Overcomes the Difficulties Encountered by Sheet Mills Driven by Pinions.

By JOSEF HIRSCHMANN,
Chief Engineer of the Eastern Rolling Mill Company.

FOR a hundred years or more balanced roughing rolls on sheet mills, have been driven by pinions despite the high cost of first installation and the expensive upkeep, to say nothing of the waste of power of this type of drive. This has been true because no other satisfactory means of doing this work had been devised, but with the great development of the sheet mill business during and since the war, and especially in the production of high-grade sheets for automobile and metal furniture work, where the necessity for a separate roughing stand became imperative, many mill superintendents, to save the extra expense of a pinion stand, adopted the old expedient of a jump roughing mill, in which the top roll is driven

by friction. This expedient has always been more or less of a makeshift and it is an open question whether the results obtained by this means ever entirely justified the saving in price from the first cost of a balanced mill.

The jumping up of the top roll on entering the sheet bar, especially on the thicker sizes, with the consequent pounding and battering up of the ends of the housing screws, which sooner or later results in crystalizing and final breaking of the screws, the reduction in output of the mill due to less draft being used in order to prevent gagging of the top roll, and the limit in thickness of bars that can be successfully roughed on a jump mill, have always been a source

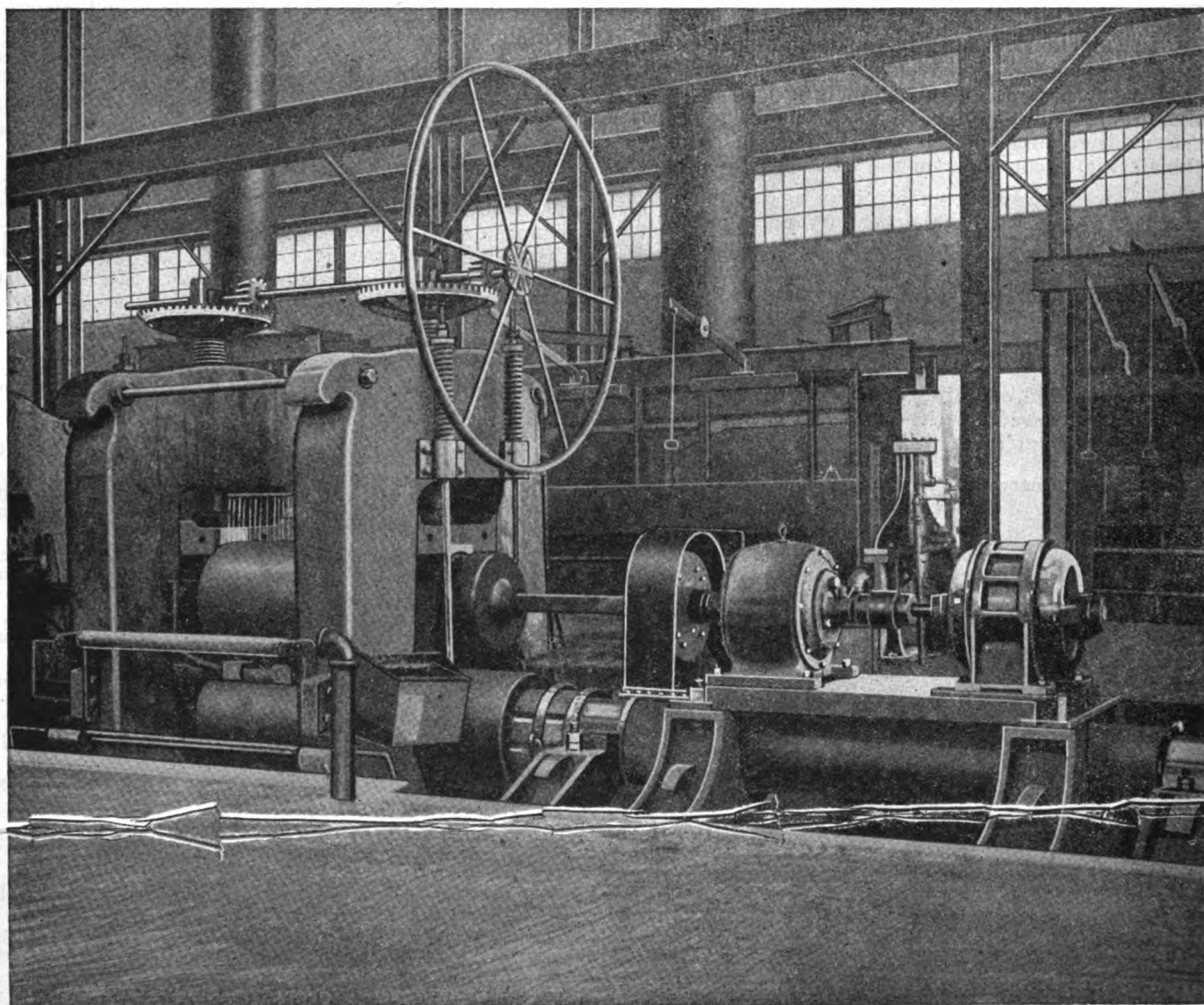


Fig. 1.

of annoyance and expense to the progressive mill superintendent.

This has resulted in the engineering genius, devoted to rolling mill construction, turning his attention to the task of solving the problem of a practical and comparatively cheap means of driving a balanced top roll.

The accompanying illustration shows a novel device designed by Josef Hirschmann, chief engineer of the Eastern Rolling Mill Company of Baltimore, Md., and assigned to the National Roll & Foundry Co. of Avonmore, Pa., who built and installed a number of these drives on the roughing sheet stands of the Eastern Rolling Mill, displacing the pinion stands previously installed.

This drive consists of a 25 hp motor at 750 rpm direct connected to a speed reducing gear transmission by means of a flexible coupling.

The transmission is a very compact nest of cut gears, with a speed reduction of 25 to 1 enclosed in a cylindrical oil tight cast iron case, permitting the gears to operate submerged in heavy oil, the same as an automobile transmission.

The central shaft of the gear transmission running at 30 rpm at the slow speed end is connected through a slip ring clutch to a short spindle and thence through an ordinary coupling box to the warbler of top roll, thus giving an ideal flexible connection, which permits the top roll to be raised or lowered to suit the thickness of the various sizes of sheet bars.

The slip ring clutch is so arranged that any excessive load, that might for any reason be thrown on to the motor beyond its stated capacity, will permit the ring to slip and prevent injury to the motor. This is taken care of by four cast iron brake shoes, held in contact with the face of the ring by an adjustable spring pressure.

However, there would be little use for this safety device as the speed of top roll is slightly slower than bottom one so that when the bar is entered into the rolls the top roll instantly becomes a friction driven roll, taking all the rolling load off the motor by running slightly ahead of the drive and dragging the armature of the motor along with it, in the direction of its rotation, thus taking care of any ordinary difference in speed between the two rolls.

Immediately the bar is out of the rolls the motor automatically takes up its task of keeping the idle top roll in motion. This arrangement does not require any special roll and any standard roll, such as a worn out finishing roll, may be used in the roughing stands.

The motor and gear transmission are rigidly bolted to the same base plate, this being superimposed upon two cast iron yoke castings straddling the roll pit, resting upon and bolted to the shoe plate on each side of pit.

These yoke castings are hollowed out at the center of the pit so that the bottom driving spindles which drives the mills through the main mill motor are free to revolve out of contact with either yoke. This gives a self contained driving unit for top roll which can be readily removed when changing rolls.

Another very desirable feature is the spring balance for top roll, attached to side of housings as shown, and through levers attached to top roll carriers, raises the top roll to the desired height when the housing screws are slackened, making a balance that is self contained with housing and permitting the

housing to be moved endwise at will when changing rolls, without previous preparation, such as blocking up of weights, as was necessary on the old weight balanced mill.

INFLUENCE OF INSUFFICIENTLY BURNT LIME.

The basic open hearth process has for its object the elimination of the phosphorus from the bath by combining the phosphoric acid, formed during melting with oxide of lime, the favorable progress of the operation depending mainly upon the physical and chemical condition of the lime.

The amount of lime used must be enough to produce a phosphate of lime, $4 \text{ Ca O P}_2 \text{ O}_5$, which contains 61.20 per cent lime and 38.38 per cent $\text{P}_2 \text{ O}_5$, corresponding to 16.93 per cent phosphorus, while at the same time by the formation of silicate of lime Ca O Si O_2 the silicon in the bath becomes neutralized and does not counteract the dephosphorization.

Difficulties in transportation sometimes cause a prolonged standing of the cars loaded with the lime on a railroad siding, during which standing the wagon covers may become more or less spoiled. Weather influences then change the oxide of lime into the hydrate, which is blown from the furnaces in the form of dust. This in turn causes an incomplete dephosphorization and very noticeable loss of heat.

Raw limestone contains 45 per cent CO_2 which is driven off by the burning.

Samples of lime containing 11.25 per cent CO_2 going as high as 23.08 per cent; 25.63 per cent CaCO_3 reaching up to even 52.45 per cent are nevertheless burnt only to three-fourth and to one-half. In this connection, however, it must be kept in mind that the way the samples are taken has a big influence upon the result.

It is proper to take from every carload a shovelful from the top, one or two from the center and one from the bottom, grind the samples, mix and analyze. The loss from burning should not exceed 3 to 6 per cent CO_2 .

After the carbonate of lime is introduced into the bath it decomposes into CaO and CO_2 . The temperature of the charge decreases. According to Backheuer (Stahl und Eisen 1918, page 748), the oxygen of the carbon dioxide seems to combine at the same time with the manganese of the bath. This bath is saturated with metallic oxides, which require a larger quantity of de-oxidizers. Since the manganese does not protect any longer the bath from the oxidation by the air, especially when the bath in the mixer does not contain more than 1 per cent of manganese, a loss of higher heat and a smaller quantity of steel will be the result of the action of the sulphur.

The heat loss is furthermore increased by losses due to the cooling of the bath by the decomposition of CaCO_3 and by violent reaction.

The decomposition of the carbonate of lime is not completed even towards the end of the operation. In fact, numerous bullets of from 2 to 10-inch diameter, float on the surface of the bath, lowering the temperature and hindering the flowing out of the slag by obstructing the tapping hole.

The inner part of these bullets consists of CaCO_3 . It is surrounded by a cover of CaO and slag.

The February, 1921, issue of the "Revue de l'Ingenieur"

Electric Annealing and Heat Treating Furnaces

Definition of Annealing, Quenching, Drawing and Tempering in Relation to Heat Treating Furnaces—General Characteristics of Electric Furnaces Discussed.

By GEORGE P. MILLS,

Electric Furnace Construction Company, Philadelphia, Pa.

IN order to better appreciate the present status and future possibilities of the electrically heated furnace as applied to the annealing and heat treatment of steels, it might be well to consider, briefly, these processes from a metallurgical point of view.

Although annealing, hardening, quenching, and drawing or tempering are familiar terms, I would like to define them for the purpose of this paper, in order to outline the field of the electric heat treating furnace to better advantage. All of these processes, of course, involve heating the metal up to temperatures which depend on the analysis of the steel, holding at these temperatures a certain period and cooling at varying rates.

The term "annealing" may be sub-divided into three headings:

First—Normalizing, which consists of heating the steel either above or just below the critical temperature, removing from the furnace and cooling in air. This process when applied to steel castings, relieves the casting strains, brought about by uneven cooling when the castings are stripped and eliminates the hard spots, which make machining difficult.

Second—Straight annealing which consists of heating above a critical temperature and holding for a short time, then cooling slowly by cutting off the heating medium and allowing the material to cool with the furnace. In continuous or semi-continuous furnaces, the material passes through a cooling chamber, so that the heat content of the heating furnace walls is retained, economy improved and production greatly increased. This treatment is used to turn out the highest grade of steel castings. Not only are the machining qualities of the castings improved, but the elongation is greatly increased at only slight expense of the ultimate strength. This form of annealing is also applied to tubes, wire, strip steel and other products that are cold rolled or drawn, in order to relieve the strain set up due to cold work.

Third—Dead annealing, which consists of heating the charge, soaking it a considerable time at the temperature, then cooling in the furnace at a predetermined rate, say 5 degrees or 10 degrees per hour. This process is used on high carbon alloy steel, such as ball bearing stock and other classes where absolutely uniform hardness tests are required. One reason for requiring this class of treatment is the finishing of the product in automatic machines, where any variation in the hardness might result in spoiled work and decreased production.

*Abstract of paper presented before the Philadelphia section of the Association of Iron & Steel Electrical Engineers and published in full in their February proceedings.

The hardening process consists of heating the metal to above the critical point and quenching. The degrees of hardness depend on the rate of cooling in the quenching. The more rapid the cooling, the harder and more brittle will be the steel.

Tempering or drawing consists of re-heating steel which has been quenched to a temperature below the critical point, varying from 450 to 1,150 degrees F., depending on the characteristics desired and cooling in air. The object of tempering is to eliminate the strain set up in quenching, render the steel more ductile, while retaining the high tensile strength produced in quenching.

Various physical characteristics can be obtained in a given steel by varying the temperature and the time element of treatment. Another important consideration in most of these treatments is that while it is essential to carry the temperature above the critical point, it is very desirable to keep very near the critical. Any excess above that actually required, tends to coarsen the finished product. In some types of furnaces, where it is impossible to determine just what is going on in the furnace, it is a usual practice to run the temperature 50 to 100 degrees F. above the actual critical as a factor of safety. In hardening and annealing, excessive time is usually allowed for soaking, in order to be quite sure that the entire mass of the part to be treated is up to temperature.

From the standpoint of the temperature and time element control, the electric furnace is ideal and is being considered in all cases where exceptionally high grade material is to be turned out. Other characteristics of the electric furnace are also being brought to the steel manufacturers' attention and undoubtedly large installations will shortly be made for the production of less expensive material.

The electric furnace of the ni-chrome ribbon resistor type consists essentially of a strongly fabricated steel shell with a heavy thickness of high grade heat insulating brick, laid in three or four courses, with all joints broken. The firebrick lining of the furnace is bonded to the heat insulating brick so as to produce a solid rugged furnace wall of from 13 to 20 inches thick. The heating element consists of ni-chrome ribbon, which is exceptionally heavy and rugged. These ribbon elements are distributed over the inside walls and in some cases, the roof of the furnace, on insulating hanger brick which are built into the firebrick lining.

A single length of ribbon constitutes each phase. Where splicing is necessary, the joint is heavily reinforced and welded. The phase terminals are brought through the furnace walls in close fitting insulating bushings to connection blocks on the outside

of the furnace. The phases may be connected either delta or Y to the power circuit, through the control panel.

As to the life of the ribbon, there are furnaces which have been operating for over two years and the ribbon shows no deterioration.

There is no reduction in area of the cross section of the ribbon due to erosion, but there is also no deterioration or crystallizing of the structure of the ribbon.

In fact, the maintenance and repair charges on the ribbon resistor type of furnace installed, have been negligible. At the temperature involved, the maximum never going higher than 1,800 degrees F., the firebrick used, as well as the hanger brick, have a coefficient of expansion very nearly zero. The result is a tight furnace, in which all mechanical strains are reduced to a minimum. The lining does not crack, spall or run. These facts are important, of course, not only from the standpoint of small maintenance costs, but there is no lost production due to shut-downs for repairs. Due to the fact that the ribbon resistor may be formed in any reasonable shape and distributed over the interior of the furnace, remarkably uniform temperatures are obtained throughout the furnace. The ribbons are distributed so that extra heat energy is dissipated inside of the furnace at the points requiring the most heat, in order to maintain uniform temperatures.

An example of this is shown by the gun treating furnace now being installed by the Electric Furnace Construction Company, which has inside dimensions of 36 feet deep by 6 feet in diameter, has a capacity of four 6 inch naval gun forgings weighing 50,000 pounds per charge. The furnace is divided into six heating zones, each controlled by an individual automatic panel. The radiation losses on the bottom and top zones are greater than on the intermediate zones, also the amount of metal to be heated is greater in the top and bottom zones than the intermediate zones. For this reason, 138 kilowatts is installed in each end zone and 110 kilowatts in each of the intermediate zones, the total installed capacity being 716 kilowatts. This arrangement insures uniform temperatures in the gun forgings throughout their entire length at all times, both during the period required for coming up to temperature and during the soaking period.

In the smaller furnaces where a single control is used, additional heat is generated near the doors by doubling the heating element back for a short distance, thus developing twice the Btu in this position of the furnace where the radiation losses are greatest.

The temperature control, which is the most important feature of the electric furnace, is operated by the "on and off" principle, that is, power is cut off when the temperature of the furnace reaches a predetermined setting and is cut on again when it falls to a predetermined setting. This operation is accomplished by means of a thermocouple which is placed on the surface of the charge, actuating a recording controller. The sensitivity of the control instrument is plus or minus $\frac{1}{4}$ of 1 per cent of the range of the chart, that is, if the chart of the instrument has a scale of from 200 to 1,800 degrees F., the range would be $\frac{1}{4}$ of 1 per cent of this range, or 4 degrees.

The "on and off" principle of temperature control has a number of advantages over the variable voltage control, in that the heating elements are designed for operation on standard power voltages, 110, 220, 440 or

550 on either single, two or three phase, 25 or 60 cycle or dc. Often, excess capacity in the existing power transformers can be used to advantage in the electric furnace. In cases where additional transformers have to be installed to take care of the furnace load, these transformers are of standard type and may be purchased to line up with existing power transformers.

The fact that the load is thrown on and off suddenly will produce no disturbance in line. On large furnaces as in the case of the gun furnace just cited, the power is controlled in sections so that only a small part of it is actually thrown on or off at any given instant. The usual maximum of a single zone is somewhat less than 250 kilowatts. The chief advantage of this method of control, however, is that it is entirely automatic and eliminates the manual operation which is necessary in rheostatic or transformer tap control.

The space occupied by the furnace is small compared with other types, especially when account is taken of the space required by fuel fired furnaces for accessory apparatus and fuel storage.

The working conditions around the electric furnace are excellent. It is cool and there are no fumes, no dirt, no noise.

Two important considerations to be taken up in the laying out of a new furnace are:

1. The relation of the size of furnace to the output. The electric furnace should be loaded to capacity at all times. If the production is expected to vary widely, two or more furnaces should be installed to insure capacity operation on the ones that are running.

2. Handling equipment and devices should be coordinated nicely with the furnace. High grade work can easily be spoiled in handling from the furnace, regardless of the fact that the furnace itself might be working perfectly.

It is the function of the furnace engineer to investigate thoroughly all the conditions pertaining to a proposed installation before making recommendations, and this, of course, can only be well done when full cooperation is given by the operating engineers. Much of the progress that has been made in the electro-metallurgical field in melting, refining and heat treating may be credited to electrical engineers, associated with the steel plants, and the progress which is made in the future in the use of this latest perfected electric furnace largely depends on the interest taken in it by members of this association.

1921 ANNUAL MEETING.

The twenty-fourth annual meeting of the American Society for Testing Materials will be held at the New Monterey Hotel, Asbury Park, N. J., from June 20 to 24 inclusive. Monday, June 20, will be devoted to committee meetings. The first session of the annual meeting will be on Tuesday morning, June 21, and the closing one on Friday evening, June 24. In about a month a provisional program including announcement of entertainment features will be sent to the members.

From present indications the meeting in June will be the largest the Society has ever held. Probably in no year in the Society's history have committee activities been greater, and a number of interesting and important reports are in prospect. Separate sessions will be devoted to several important subjects.



Development of Mechanical Soot Blowers

Recording Some Most Recent Tests of Mechanical Soot Blowers With Coal, Pulverized Fuel and Oil—Marked Increases in Boiler Efficiency Are Shown by Use of Mechanical Soot Blowers.

By ROBERT JUNE,
Mechanical Engineer.

PART II

SOOT as found in steam boilers varies considerably in appearance and composition, depending upon the grade of coal burned, conditions of combustion, and part of the furnace from which the sample is taken. Nearest the fire the deposits formed consist largely of ash. Analysis of samples of soot, taken from a boiler, shows in addition to the "pure soot"

furnace and striking the boiler they adhere to the tubes. If this deposit is not removed frequently it quickly increases in amount and changes in character. The carbon burns out in part and the mass cements together. The repeated reduction in heat-absorbing surface increases the temperature of the flue gases, so that the process of cementation is con-

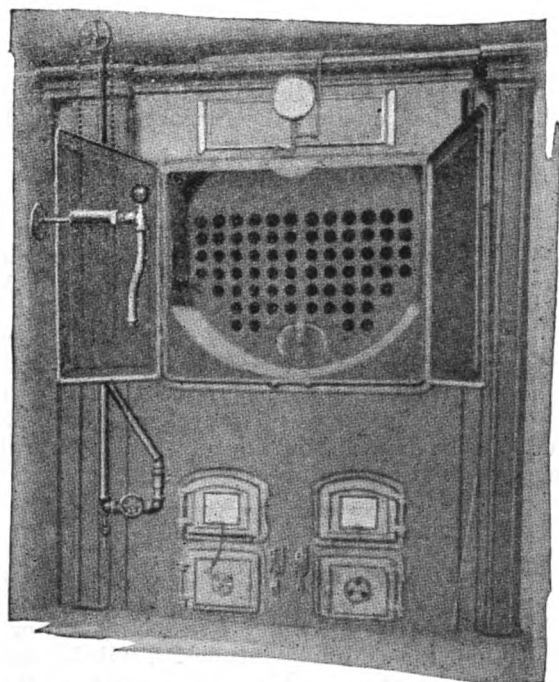


Fig. 1—Typical installation of Diamond Soot Blower system on a horizontal return tubular boiler. Door is shown transparent in order to show piping and method of operating main blower valve from floor.

the presence of silica, alumina, iron oxide, various alkalis and sulphur dioxide.

In all but the coolest portion of the setting, soot is usually gritty in texture. The grains may be as large as medium size sand or as fine cigar ash. These particles are in a plastic state when they leave the

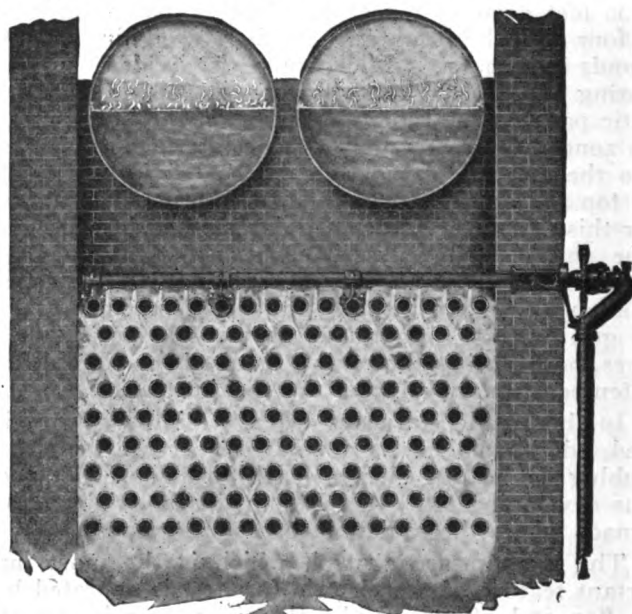


Fig. 2—Detailed view of the Diamond Model G revolving unit installed in a horizontal water tube boiler. The method of supporting blower units on tubes, and the position of the units and nozzles relative to the tubes, is practically the same on all types of horizontal and vertical water tube boilers to which this system can be applied. Notice there is a Venturi nozzle for every space between the rows of tubes.

tinuous and constantly increasing in intensity. If extremely hard, clinker-like formation results. In a short time the tubes in some portion of the boiler are thickly coated, thus materially reducing its capacity.

In our discussion last month we dealt with figures

of actual tests conducted to determine the efficiency of mechanical soot blowers with various types of fuel, such as anthracite and bituminous coal, pulverized fuel and oil. We found that mechanical soot blowers would effect a saving of 4 to 8 per cent in fuel and also effect an important reduction in labor, so that the importance and value of mechanical soot blowers was self evident.

The Five Essentials in Preventing Soot Waste.

The five essentials in preventing soot waste are:

1. Frequency of cleaning in order to minimize the cumulative effects of increasing deposits. Tubes should be cleaned three or four times in 24 hours.
2. Thoroughness of cleaning, in order to maintain high furnace and boiler efficiency, and prevent the corrosive effects of soot accumulation.
3. Availability of system. The soot cleaner system should be instantly available, automatic in action, capable of rapid operation.
4. Durability of system: The blower units should be so designed and constructed that they will withstand the stress of hard service without the necessity for frequent repair or replacement.
5. Economy in operation: The soot removing system should be cheaper in operation than hand blowing; it should be so installed as to prevent the entrance of cold air into the furnace during its operation, it should not interfere with the operation of the boiler; it should pay for itself from an investment standpoint.

Soot Blowers for Horizontal Return Tubular Boilers.

Soot blowers were first manufactured on a commercial basis for Scotch marine boilers on the Great Lakes. The blowers were what is known as the "Rear end" type, being installed through an opening in the water leg in the rear. It was only natural therefore, when soot blower manufacturers began to develop equipment for stationary horizontal return tubular boilers that they should start in by adopting

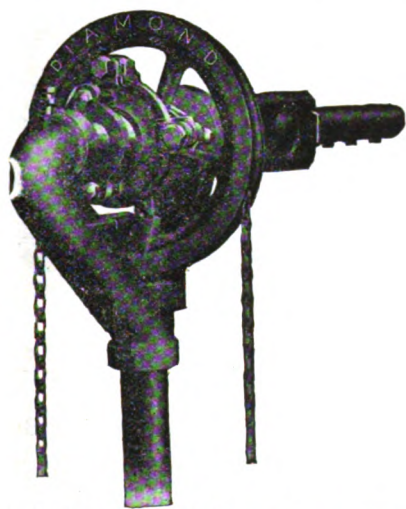


Fig. 3—Head of Model "G" Unit used on water tube boilers. Note the strong symmetrical construction. The use of the gooseneck permits the steam main to be brought close to the boiler setting, thus adding greatly to the appearance of the installation.

the rear end blower on Scotch Marine boilers for this purpose.

For a good many years it was the universal practice of all soot blower manufacturers to make only rear end equipment for horizontal return tubular boilers. The rear end blower had numerous disadvantages, however, and about 8 to 9 years ago soot blower manufacturers generally began to produce

front end blowers. While rear end blowers can still be purchased from one or two of the older manufacturers, they are seldom recommended, and practically every manufacturer of this type of equipment manufactures and recommends the front end blower to the exclusion of the older type.

A typical installation is shown in Fig. 1. This

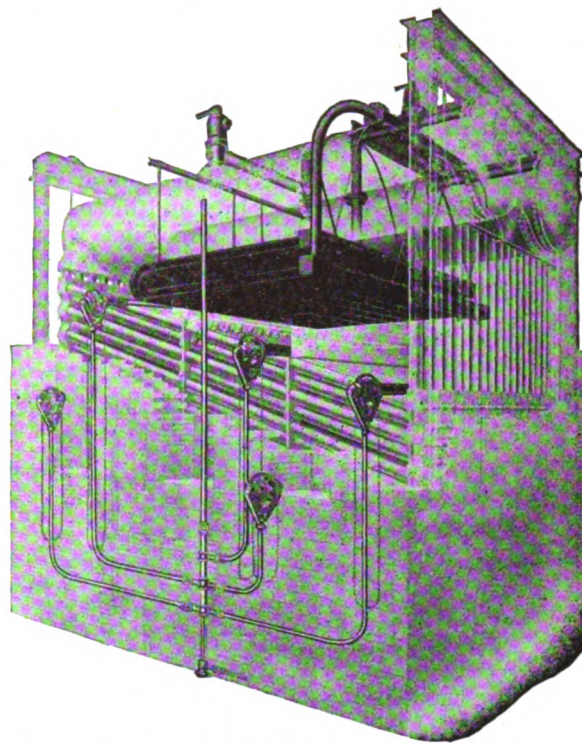


Fig. 4—Application of the Diamond Mechanical Soot Blower system to horizontal water tube boiler, vertical baffle type with superheater.

consists of a blower arm inset with Venturi nozzles and placed at the front end of the boiler. The position and arrangement of the blower are such that when it revolves, the nozzles direct the steam jets directly into every tube of the boiler. With an initial pressure of 150 pounds this steam is shot from the nozzles at a velocity of approximately 2,700 feet per second. As can be imagined, the effect is to remove every bit of the soot and fine ash deposit.

The blower unit is attached to the door, and when the door is opened the entire mechanism swings with it, leaving the boiler ends free and clear for inspection, repairs, etc., and exposing and making easy of access any part of the blower.

Both the tubes and the combustion chamber are cleaned at the same time. The sweeping of the arm as it swings in a complete circle allows the steam to be shot directly into the tubes on a straight line and the corner tubes are taken care of with the same thoroughness as the center ones.

The blower being at the front end of the boiler, and the entire mechanism controlled from the outside, it is easy to get at and operate, making the cleaning of the boilers three or four times a day a simple process. Each operation will consume only about a minute's time.

One of the most important advantages in the use of mechanical soot blowers is the absolute exclusion of cold air from the boiler. The boiler doors are always shut tight when the blowers are in opera-

tion, and it makes no difference what load the boiler is under. In fact, the more the boilers are being forced, the more need to clean the tubes. This cleaning cannot be done with a hand hose without reducing the load. It can be done in a few moments right at the peak of a load with mechanical soot blowers and all of this is accomplished without any reduction in efficiency caused by admission of air.

Equipment for Water Tube Boilers.

For cleaning water tube boilers of the usual horizontal type, vertically baffled, and for cleaning most types of vertical boilers and economizers, the equipment supplied by the principal manufacturers commonly consists of a permanent installation of revolving units located at various points in the passes of the boilers. In a typical installation, Figs. 2 and 3, the equipment consists of five principal elements, as follows:

1. A head through which the steam passes from the main

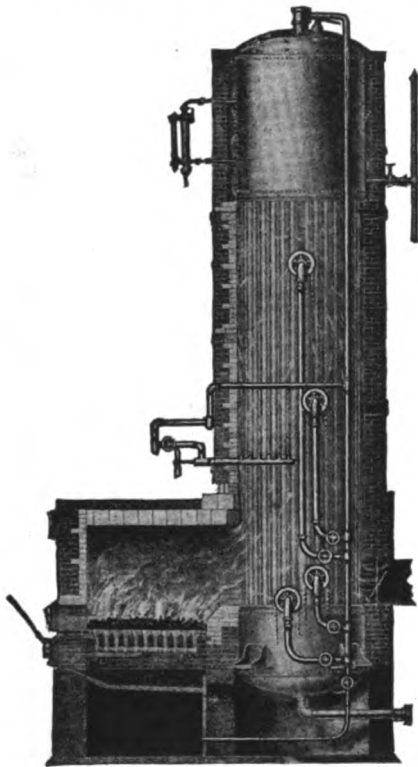


Fig. 5—Installation of Diamond Soot Blowers on Wickes vertical boilers.

soot blower supply line when the valve is opened. The head is the foundation element to which the other elements are attached.

2. A wall box which is bricked into the setting. The box supports the unit, and is so constructed that the blower can be turned freely without admitting air to the inside of the setting.

3. A blower element running cross-wise of the bank of tubes and consisting of a small header with nozzles so placed as to discharge steam between the boiler tubes.

4. A sheave or hand wheel by means of which the blower element is rotated.

5. Bearings attached to the boiler tubes which support the blower element and permit it to revolve freely.

Soot Blowers for Horizontal Water Tube Boilers.

The general arrangement of the units in horizontal water tube boilers consisting of a single bank of tubes is shown in Fig. 4. It will be noted that a unit is shown over the arch at the bottom of the first pass.

This is extremely important in as much as this is the point where the gases first strike the boiler and where the largest deposits of soot and ash are to be found. This is also the hardest working part of the boiler, as the temperatures are highest here and the transfer of heat to the water is most rapid.

In order to maintain this rapid transfer of heat, the deposits of soot and ash must be removed at frequent intervals. As the temperatures are extremely high at this point, the problem has been presented to soot blower manufacturers in designing a unit which would stand up and perform its functions satisfactorily. The problem has been solved by treating the unit by a special process known as "calorizing" to prevent the burning of the metal at high temperatures and by placing the unit close against the front header of the boiler behind an arch that the blower unit will stand up in this location for six months to three years and in some cases even longer. As the cleaning of this part of the boiler is of vital importance, power plant operators have found that they can well afford to replace the blower pipe of this unit from time to time as conditions warrant.

The second unit is located at the top of the first pass in a position which enables it to clean the superheater as well as the boiler tubes. The frequent cleaning of the superheater is essential to the maintenance of high and uniform steam temperatures, and an individual soot blower unit for this purpose is frequently provided. The remaining units in the boiler are located at strategic points in the passes.

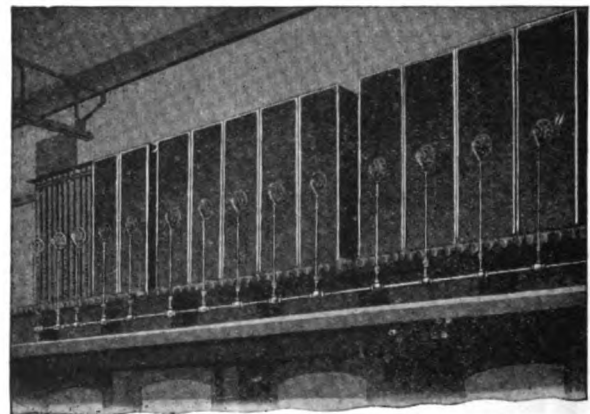


Fig. 6—Independent type of economizer equipped with Diamond Soot Blowers instead of scraper mechanism.

Soot Blowers for Vertical Water Tube Boilers.

The world's largest boilers are of the vertical type and it is a notable fact that these large boilers, almost without exception, are equipped with mechanical soot blowers. Proper arrangement of the units is one of the most important factors in the success of these installations. In the Stirling, Connelly, Kidwell and similar boilers thorough cleaning of the tubes at the bottom of the first pass is secured by the installation of calorized units. Temperatures are high at this point and the calorized metal withstands high temperatures without oxidizing.

One of the principal requirements of a successful soot blower installation for vertical boilers is that the system employed shall allow the steam jets to play effectively over the whole gases by unnecessary obstruction. The number and location of the units

in vertical boilers varies with the different sizes and types of generators. The number of units will run from five in the small Stirling boilers without superheater to 32 in the big W-type of 2,365 hp, such as are used at the plant of the Detroit Edison Company and other large central stations.

With Wicks boilers, Fig. 5, the problem of design is complicated by the fact that economy in space is one feature of Wicks installation and that the boilers are therefore often set in solid batteries, rendering it difficult to get at the lower part of the rear pass.

Tubes over the arch are cleaned by means of a special removable unit. This unit consists of a multiple jet blower element with one nozzle for each row of tubes. A universal joint of steam-tight design permits easy operation of the unit and insures thorough cleaning of this section of the boiler. The unit is permanently secured to the boiler shell, and when not in use can be withdrawn from the tube space out of the heat—a desirable feature in such installations as have temperatures in excess of 2,000 degrees.

Economizer Installations.

The same type of units used to clean boilers are now being generally used for the purpose of removing soot and ash deposits from economizers, whether the latter are an integral part of the boiler or independent units. Fig. 6 shows the method of installation. The arrangement provides for units extending from front to back of economizer centrally located between the top and bottom and spaced 4 or 5 rows of tubes apart.

We have stated that soot blowers are going into use on economizers, replacing the old type scraper mechanism. The advantage of soot blowers as compared with the scraper are:

a. Elimination of air infiltration. For every 10 to 16 tubes, depending upon the capacity of the economizer, there is a chain provided for the raising and lowering of the scrapers. These chains pass through holes in the top of the economizer. As these holes are always open, air infiltration is a constant source of loss—a loss which is eliminated when soot blowers are installed.

b. One of the conditions always encountered in some degree in economizer installations is the piling up of soot on the bottom headers. While it is true that a space is provided between the headers which would seem to be ample for the soot to fall through into the soot chamber, yet quantities of it are always building up in the space between the headers and eventually bridging over. As this result the action of the scrapers is interfered with and the efficiency of the economizer is affected by reason of the accumulation. This difficulty is always removed by the use of soot blowers.

c. The scraper mechanism takes from 2 to 5 hp of electric power to operate. There is constant charge for power. Scraper maintenance is also one of the most costly features of economizer installation. In addition to the cost of operation and maintenance there is also the handicap of making repairs to the tubes of the economizer. While soot blowers require some operating charges, these charges are very low when compared with scrapers, and in addition the economizer is cleaned more efficiently.

Equipment for Hollow Stay Bolt Boilers.

For hollow stay bolt boilers the soot blowers con-

sist of two main pipes from which extend many branch pipes carrying Venturi nozzles. One of these nozzles enters every hollow stay. The system is so arranged that it clears the hand-hole yokes, permitting them to be removed, and thus making the tubes easily accessible for turbinizing or repairs without disturbing the blower in the least. The entire equipment is permanently installed on the front water-leg of the boiler, and is operated by two valves only, from the front.

Where boilers are built with horizontal baffles, a number of the nozzles are extended over the baffles for distances of from two to eight feet, thus insuring a high degree of efficiency in cleaning. In addition to the use of blower nozzles extending from the stays, it is at times found possible to equip boilers of this type with revolving units, as well, and this combination equipment offers the most satisfactory method of securing high cleaning efficiency in this type of boiler.

Recent Advances in Design and Construction.

One of the most important recent advances in

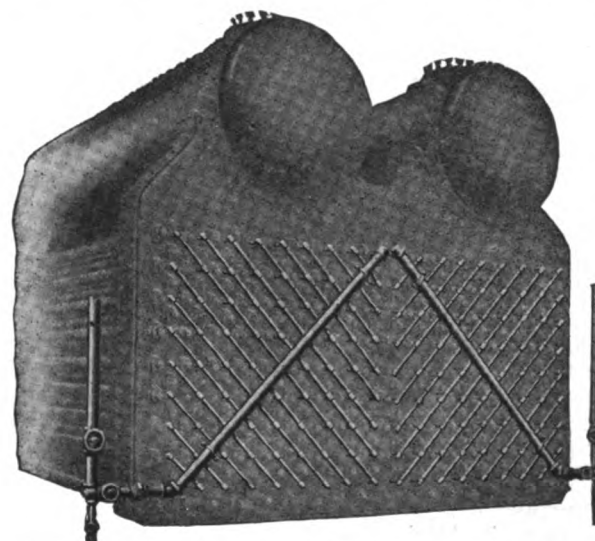


Fig. 7—Installation of Diamond Soot Blowers on water tube boiler with hollow stays.

design and construction from the point of view of increased efficiency is the development of the vertical header type of installation, Fig. A. This design presents many advantages as compared to the old practice of placing the header in a horizontal position which may be summarized as follows:

1. Increased effective pressure of steam at blower nozzles, due to the elimination of a number of right angle joints and the reduction of friction at the fittings.
2. Permits free expansion of all riser pipes, thus preventing any possible binding of the units.
3. Eliminates a number of screw joints with consequent reduction in opportunities for leakage to develop.
4. More securely fitting doors, etc., than when horizontal header or right angle joints are employed.
5. Presents much better appearance mechanically.
6. Permits the use of a much shorter header.
7. Valves are concentrated at one point, facilitating rapid operation.
8. Assures thorough draining.

In addition to these special merits, it can be installed as quickly as the horizontal header with its right angle joints and the cost is, if anything, but little more.

Welded Nozzles.

When nozzles of Venturi section were developed the problem of high velocity as far as soot blowers were concerned was solved for all time. The method of fixing the nozzles in the blower elements, however, has been subject to considerable improvement in the past few years. Originally, nozzles of all soot blower units were simply screwed in place. Experience showed that the hot gases were continually attacking the threads and that oxidation at this point was much more rapid than elsewhere, with the result that after the blower elements had been in use but a short time, the nozzles became loose and in the course of time dropped out, thus rendering the blower element ineffective. To overcome this difficulty a method of welding the nozzles in place has been developed and is now in commercial use.

The same trouble which developed with screwed nozzles developed with the screwed plugs which were originally used to close the ends of soot blower elements; that is, the gases attacked the threads with the result that the plugs became loosened and at times blew out. In order to overcome this difficulty, caps were welded on the ends of the blower elements. This construction has however recently been modified and greatly improved by placing a disc of steel inside the blower element, then swaging the end thus partly closing it, and then welding the plug in place, completely closing the end so that there is no possibility of the plug being blown out by the steam.

Probably no feature of soot blower construction has been subject to so much study and improvement as have the bearings which support the units inside the boiler. These bearings were originally made of cast iron, but in the last year a special type of steel bearing has been presented which has innumerable advantages over the old style cast iron bearings. The advantages of the steel bearing are the closer grip on the boiler tube, less transfer of heat, less likelihood of working loose from the boiler tube, etc.

Illustrations to accompany this article furnished by courtesy of the Diamond Power Specialty Company, Detroit, Michigan.

ECONOMICAL FIRING OF STEEL PLANT BOILERS.

(Continued from page 310)

- (a) Equivalent evaporation per hr. per sq. ft. of boiler heating surface based on water entering boiler 2.31 lbs.

Capacity**Based on Temperature of Feed Water Entering Economizer.**

31. Equivalent evaporation per hour from and at 212 degrees.....25,423.7 lbs.
(a) Boiler horsepower developed.. 736.9 bhp
32. Rated capacity per hour from and at 212 degrees17,940 lbs.
(a) Rated boiler horsepower..... 520 bhp
33. Percentage of rated capacity developed 141.7%

Capacity**Based on Temperature of Feed Water Entering Boiler.**

34. Equivalent evaporation per hour from and at 212 degrees.....23,350 lbs.
(a) Boiler horsepower developed.. 676 bhp

35. Rated capacity per hour from and at 212 degrees17,940 lbs.
(a) Rated boiler horsepower..... 520 bhp
36. Percentage of rated capacity developed 130%

Economy of Economizer and Boiler.

37. Water fed per lb. of coal as fired.. 8.49 lbs.
38. Water evaporated per pound of dry coal 9.04 lbs.
39. Equivalent evaporation per lb. of coal as fired 10.63 lbs.
40. Equivalent evaporation per lb. of dry coal 11.31 lbs.
41. Equivalent evaporation per lb. of combustible 13.04 lbs.
42. Calorific value of 1 lb. of dry coal by calorimeter12,610 Btu.
43. Calorific value of 1 lb. of combustible by calorimeter15,013 Btu.
44. Efficiency of boiler, economizer and furnace 87.03%
45. Efficiency based on combustible.... 84.28%

Economy**Based on Temperature of Water Entering Boiler.**

46. Water fed per lb. of coal as fired.. 8.49 lbs.
47. Water evaporated per lb. of dry coal.. 9.04 lbs.
48. Equivalent evaporation per lb. of coal as fired 9.76 lbs.
49. Equivalent evaporation per lb. of dry coal 10.36 lbs.
50. Equivalent evaporation per lb. of combustible 11.95 lbs.
51. Calorific value of 1 lb. of dry coal by calorimeter12,610 Btu.
52. Calorific value of 1 lb. of combustible by calorimeter15,013 Btu.
53. Efficiency of boiler and furnace.... 79.87%
54. Efficiency based on combustible.... 77.26%
55. Proximate
- (a) Moisture94%
- (b) Volatile matter 29.92%
- (c) Fixed carbon 52.56%
- (d) Ash 17.52%
- (e) Sulphur 1.28%

Analysis of Flue Gas.

56. (a) Carbon Dioxide (CO₂)..... 8.27%
- (b) Oxygen (O₂) 8.83%
- (c) Carbon monoxide (CO)..... .166%
- (d) Nitrogen (N) by difference... 82.734%
57. Analysis of

**Combustion
Ash Retained**

- (a) Moisture 14.7%
- (b) Combustible 0.0%
- (c) Earthly matter 85.3%

Heat Balance Based on One Pound of Combustible.

- | | Btu. | Per cent |
|---|--------|----------|
| (a) Heat absorbed by the boiler... | 126.54 | 84.28 |
| (b) Loss due to evaporation of moisture in coal | 12.654 | .084 |
| (c) Loss due to heat carried away by steam formed by the burning of hydrogen | 556.6 | 3.7 |
| (d) Loss due to heat carried away in dry flue gases..... | 990 | 6.59 |
| (e) Loss due to carbon monoxide... | 143 | .952 |
| (f) Loss due to combustible in ash and refuse | 0 | |
| (g) Loss due to heating moisture in air | 45.1 | .30 |
| (h) Loss due to unconsumed hydrogen and hydro-carbons, unaccounted for and radiation... | 513.0 | 4.08 |
| (i) Total calorific value of 1 lb. of combustible | 15,013 | 99.98 |

FOREIGN RELATIONS

THE IRON AND STEEL INDUSTRY IN LUXEMBURG

By SAMUEL H. CROSS,

Acting Commercial Attaché, Brussels, Belgium.

The projected economic convention between Belgium and the Grand Duchy of Luxemburg, against which Belgian metallurgical interests have protested, invites attention to the high development of the iron and steel industry in the Grand Duchy. It possesses five groups of iron and steel producers, controlling 70 blast furnaces, of which 23 are scattered in the Saar Basin, Lorraine, and Belgium, while 47 are located in Luxemburg itself.

Plants in Operation.

The largest of the Luxemburg plants, the Société Anonyme des Aciéries Réunies de Burbach-Eich-Dudelange (United Steel Works Company, familiarly known as the "Arbed," from its initials), which owns large ore deposits in France and Luxemburg, has at Burbach in the Saar Basin one section comprising 8 blast furnaces, of which 3 are in operation; 1 Thomas and 1 Martin converting installation; 14 rolling trains; and some construction shops. At Dudelange it owns six blast furnaces (three in operation), the same converting plant as at Burbach, and in addition a foundry and seven rolling trains. This company also operates at Dommeldange construction shops, a steel foundry, Martin converters, and an electric steel plant with three furnaces; the three blast furnaces at Dommeldange are not fired at present. The "Arbed" likewise runs at Esch-sur-Alzette seven rolling trains, a Thomas converting plant, and three of the six blast furnaces installed there.

The Ougrée Marihay Company, which is actually a Belgian concern with its center of business at Ougrée, on the Meuse just south of Liège, has a section at Rodange, Luxemburg, with five blast furnaces (four in operation), having an annual production capacity of 125,000 tons, and a Thomas steel plant, as well as foundries and rolling mills. The Ougrée-Marihay plants secure their ores from the Grand Duchy and French concessions, their resources in this connection totaling 6,516 hectares. The Steinfort Blast Furnace & Steel Mill Co., at Steinfort, now has one of its three blast furnaces operating and is planning the construction of rolling mills and a steel plant; its ores are located in the Esch Basin. It has lately taken over the Rhenish Steel Works, at Duisburg-Meiderich.

The Société Métallurgique des Terres Rouges (Red Earth Metallurgical Company), at Esch-sur-Alzette, has 4 blast furnaces at Audun-le-Tiche (Lorraine), 5 furnaces at Esch-sur-Alzette, and 6 others at Bel-Val, with Thomas converters and 10 rolling trains, having a capacity of 1,000,000 tons of steel annually. None of the furnaces at Esch are operating, but two are fired at Bel-Val and five at Audun. The fifth metallurgical group, that of the Société Anonyme des Haut Fourneaux et Aciéries de Differdange-St. Ingbert Rumelange, familiarly known as the "Hadir," has 3 blast furnaces at Ottange (Lorraine), 3 at Rumelange, and 10 at Differdange, with a steel plant and 8 rolling trains at the last-named division. Four of the furnaces at Differdange are in operation, and one at Ottange.

The proximity of the Luxemburg steel plants to the ore deposits gives them an appreciable advantage over their Belgian competitors, who since the war have not received the preferential freight rates on the Belgian railways which

until 1914 placed them in a privileged position. The opposition to the Belgian-Luxemburg economic convention therefore emanates entirely from blast-furnace operators, while the steel plants and rolling mills who purchase their pig iron instead of producing it would welcome lower prices on this commodity.

BELGIAN STEEL PLANTS FORM COMBINE.

Acting Commercial Attaché Cross of Brussels, Belgium, cables under date of March 9 that a number of Belgian steel plants have formed a combination for joint action after recovery from war damages. This combination is formed for the purpose of distributing raw materials and for the sale of finished products and replaces the former Comptoir des Aciéries Belges. The following companies compose the organization: Cugree, Marihay, Cockerill, Providence, Angleur, Hainaut, Thy le Chateau, Althus Grivignee, Esperance Longdoz, Clbecq, Moncheret, Bonehill, Halanzy and Chatelineau.

THE GERMAN METAL BAROMETER INDUSTRY.

By HOWARD W. ADAMS,

Representative of the Department of Commerce, Berlin.

At present there are eight plants in Germany engaged in the manufacture of metal barometers. These plants are located in Hamburg, Stuttgart, Berlin, and in Buetzow in Mecklenburg-Schwerin. The number of workmen now employed in this industry is 300.

During the war the demand for the products of this industry was very limited. Upon the cessation of hostilities business began to pick up and continued to improve through 1919, reaching its culmination in an unusually brisk Christmas trade in that year. This industry since the close of the war has been subjected to many handicaps which have caused production to fall far behind that of pre-war years. Among the difficulties encountered have been the lack of raw material, especially metal and glass, strikes and other labor troubles, together with an insufficient supply of electric power, this latter condition at times existing for weeks at a time. As a result of this situation old customers could only partially be supplied, whereas no deliveries whatever could be made to new purchasers.

In the meantime, the prices of metal barometers reached a figure which has been prohibitive so far as the German consumer is concerned. Furthermore, the countries which had been placing big orders for metal thermometers with German manufacturers have for some time been curtailing their purchases. In many cases foreign buyers have canceled their orders.

SLAG AS A ROAD MATERIAL IN INDIA.

Interest is being taken in the use of slag material in India. It is found to be valuable in making tar bound macadam roads, which are taking the place of water bound macadam. It is stated that slag has a special affinity for tar but it must, however, be carefully selected by rejecting all porous material. In view of the fact that the iron and steel industry is commanding greater attention in India, this use of slag is considered timely.

NEWS OF THE PLANTS

The Maryland Steel Rolling Company, Fidelity Building, Baltimore, Md., recently organized with a capital of \$200,000, has plans under way for the construction of a new local plant at Eighth and Monument streets, to be used as a steel reclaiming mill and general steel works. The plant will specialize in the production of iron and steel bars of small sizes, produced from high quality scrap. The machinery for the most part will be electrically operated, and the works will include an open hearth furnace. This latter installation will be increased at an early date. The initial plant will have an output of about 15,000 tons of material per year. It is proposed to commence construction at an early date and have the new plant ready for service during the coming summer. J. G. Miller is president of the company; Reuben S. Baldwin, general manager and J. H. Dashfield, treasurer.

The Trumbull-Cliffs Iron Company, Warren, O., has construction well under way on a new blast furnace of 600 tons capacity and expects to have the plant ready for service early in the summer. The new furnace is about 20 per cent larger than the customary type of plant and represents an investment of about \$3,250,000. The Trumbull-Cliffs Company is owned jointly by the Trumbull Steel Company, Warren, and the Cleveland-Cliffs Iron Company, and practically the entire output of the furnace will be utilized at the plant of the first noted company. This company also has an option to purchase the furnace at the expiration of a certain period of time. Jonathan Warner is president of the Trumbull Steel Company.

The Northwest Iron & Steel Co., Rookery Building, Spokane, Wash., is planning for the construction of a new iron plant at Leadpoint, in the boundary district of Stevens County. The new plant will be used for the production of pig iron and will have an initial capacity of about 25 tons of this material per day. The output will be increased with the installation of additional equipment at an early date. E. C. Owen is superintendent.

The Youngstown Steel Company, Youngstown, O., will defer the erection of its proposed new plant at Warren, O., until a later date. The works were to be used for the manufacture of puddled iron under a new mechanical process perfected by E. L. Ford, president of the company.

The Wheeling Steel Company, Wheeling, W. Va., has arranged a fund of \$3,000,000 for the erection of additions to its plant at Steubenville, O., operated by the LaBelle Iron Works, a subsidiary organization. The work will consist of a number of buildings with the installation of considerable new equipment. Details of the project are being arranged.

The Southwest Steel Company, Springfield, Mo., is planning for extensions and improvements in its plant for increased production. New machinery will be installed, including steel converters. Work will be inaugurated at an early date.

The Chapman-Price Steel Company, Indianapolis, Ind., has commenced operations in its new mill, recently completed. It is to be used for the rolling of sheets. Two mills of this kind are now in operation, with production used by

the company in connection with the fabricating branch of its business. The installation at the new mill consists of four finishing mills, two roughing mills and two cold mills. The equipment is electrically operated with motor drive. Other machinery includes squaring and bar shears, four combination sheet furnaces, galvanizing equipment and two double annealing furnaces with auxiliary operating equipment. The plant will be developed to a capacity of 25,000 tons of sheets per annum. Niles Chapman is president of the company; L. H. Price, is treasurer and general manager of sales.

The Dominion Steel Corporation and the Nova Scotia Steel & Coal Co., Montreal, Can., are arranging merger plans with the Halifax Shipyards, Halifax, N. S., the combined company to operate under the name of the British Empire Steel Corporation.

The Allegheny Steel Tank Car Company, Warren, Pa., is said to be planning for the immediate rebuilding of the portion of its plant destroyed by fire recently with a loss estimated at about \$100,000, including equipment.

The Midland Steel Products Company, 3136 South Canal Street, Chicago, Ill., has awarded a contract to Holton, Seelye & Co., 140 South Dearborn Street, for the erection of a one-story addition to its plant, to be 25 x 125 feet, located at 1752-58 East Seventy-fifth Street, and estimated to cost about \$55,000.

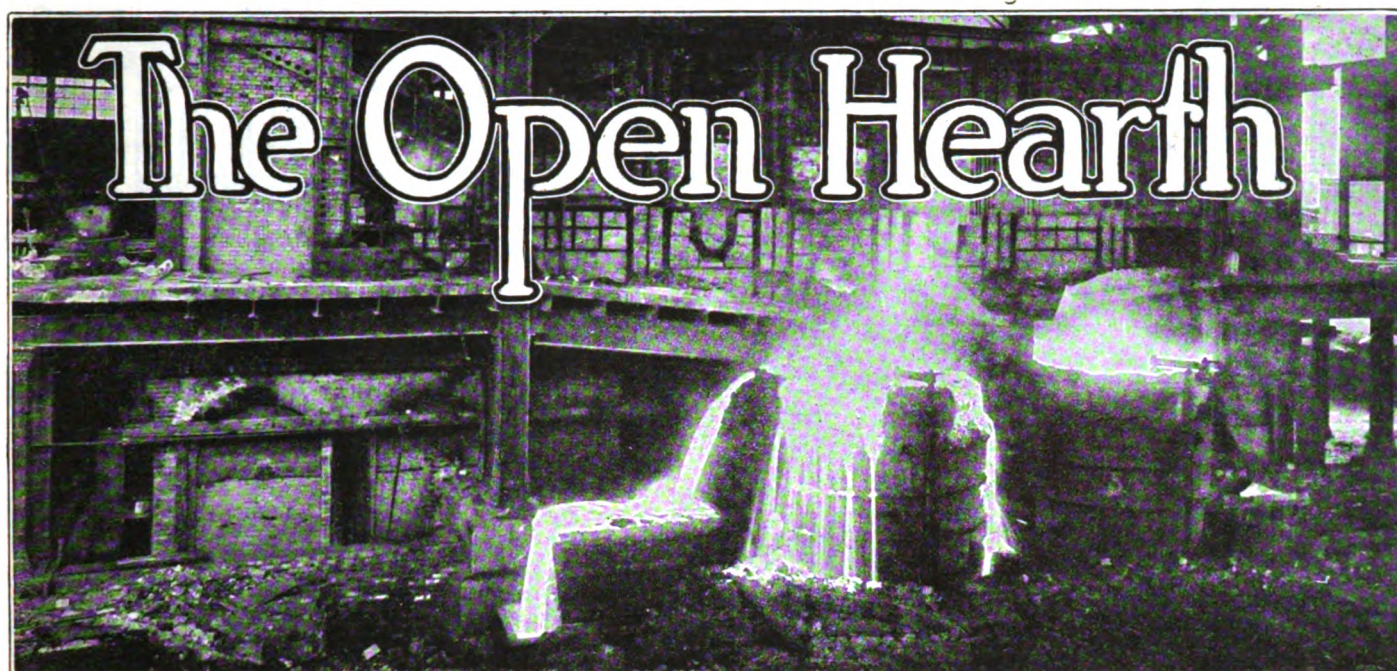
The Willamette Iron & Steel Co., Portland, Ore., has perfected plans for the erection of a new plant on the shipyard site formerly occupied by the Foundation Company. The works will consist of a number of buildings, estimated to cost about \$250,000 with machinery. Permits have been taken out to cover the construction of the initial plant units.

The Vulcan Iron & Steel Co., Muncie, Ind., recently organized with a capital of \$300,000, has plans under way for the establishment of a local plant for the manufacture of bar iron and steel. Details of the works are being arranged. The plant will operate under a special process perfected by Llewellyn Jones and Charles Westlake, Jr., Youngstown, O. R. Milt Retherford is president of the new company and Walter L. Nelson, treasurer, both of Muncie.

The Erie Crucible Steel Company, East Twelfth Street and Downing Road, Erie, Pa., has taken bids for the erection of an addition to its plant to be equipped as a rolling mill. The extension will be one-story, 60 x 100 feet, and is estimated to cost about \$75,000. Frank H. Payne is president.

The Michelman Steel Construction Co., 137 North Second Street, Quincy, Ill., has completed plans for the erection of an addition to its plant for increased production, to be 100 x 140 feet, and estimated to cost about \$450,000 with machinery.

The Beaumont Iron Works Co., Beaumont, Tex., has plans under way for the erection of an addition to its plant for increased production. It will be one-story, and is estimated to cost about \$60,000 with equipment.



Mr. George B. Troxell connected with the Bethlehem Steel Company, at Bethlehem, Pa., the past five years has resigned as assistant superintendent of the electric furnace and crucible departments. He is considering a South American project.

V V

Henry W. Seldon has resigned his position as head of the service department for Amsler-Morton Company and has joined Mr. Theo. S. See in forming the company of See-Seldon & Associates, industrial and combustion engineers, with offices in the Oliver Building. Mr. Seldon is a graduate metallurgical engineer of the Carnegie Institute of Technology and prior to his experience in the glass industry was engaged for ten years in practical engineering and operating work with the Cambria Steel Company at Johnstown, Pa. and the Jones & Laughlin Steel Co. at Pittsburgh, Pa. The new company is engaged in consulting and operating engineering and makes possible for all manufacturing plants a production and efficiency service which has heretofore not been available.

V V

W. C. Peterson, for the past 12 years in charge of the metallurgical laboratories, heat treating departments and research work, respectively, of the Packard Motor Car Company, Detroit, has resigned to take charge of the metallurgical department of the Atlas Crucible Steel Company at Dunkirk, N. Y., where he will undertake a similar character of work. He is a member of several committees of various national metallurgical and engineering societies.

V V

Hugh Ferguson of Pittsburgh, has been elected president of the Missouri Iron & Steel Corp., Haigart, Mo., succeeding W. R. Haight of St. Louis, resigned. G. M. Thompson, who has been acting president, was elected vice president and E. J. Shroder of Breese, Ill., was made second vice president.

V V

E. H. Weitzel, who has been manager of the fuel department of the Colorado Fuel & Iron Co., Denver, for the past 13 years, was appointed general manager of the company March 21, succeeding the late J. B. McKennan. His first coal mining experience was received in the Pittsburgh dis-

trict. In 1903 his wife's illness forced him to move to the West. He gave up his position as general superintendent of the Empire Coal Company, Bellaire, O., and went to Dawson, N. M., where he took employment as a coal digger. After three years in various capacities he opened an office in Trinidad, Col., and in 1907 was appointed chief engineer of the fuel department of the Colorado Fuel & Iron Co. He was made manager of the department in 1908.

V V

C. W. Doty, formerly general manager of the Nettleton Steel Treating Company, Cleveland, is head of the Doty Steel Products Company, Los Angeles.

V V

John W. Mowery, plant engineer Chester Shipbuilding Company, Chester, Pa., has been made general manager of the Worcester Pressed Steel Company. Mr. Mowery is a Cornell man.

V V

Fred Crolus, steam engineer, Carnegie Steel Company, Homestead, Pa., will deliver a very interesting paper on "Powdered Coal and Its Application to Boilers" on May 14 at the Chatham Hotel. This meeting will be under the auspices of the Combustion Committee of the Association of Iron & Steel Electrical Engineers. Frank Leahy, fuel and experimental engineer of the Carnegie Steel Company, Duquesne, Pa., will act as chairman of the meeting.

V V

Paul Driscoll, general sales manager of the Penn Seaboard Steel Corporation, Philadelphia, and formerly with the Carnegie Steel Company and the Lackawanna Steel Company in their Philadelphia offices, has resigned. He will become sales representative in New York and Philadelphia for the Niagara Metal Stamping Corporation, Buffalo, of which C. R. Robinson, formerly general manager of sales of the Lackawanna Steel Company, is the head.

V V

Charles A. Williams, for 25 years connected with the lake trade, has been appointed lake traffic manager for the Jones & Laughlin Steel Co., Pittsburg, and the Interstate Steamship Company, with headquarters in Cleveland.

V V

George B. Nesbit, chief metallurgical engineer of the



Brier Hill Steel Company, Youngstown, O., has resigned to become associated with the International Smelting & Refining Co., Erie, Pa., as production manager.

✓ ✓

R. B. Randall has been appointed manager of southwestern territory for the Blaw-Knox Company, Pittsburgh, and has established offices for the company in the Interstate Building, Kansas City, Mo.

✓ ✓

Evan F. Jones, who resigned as president and general manager of the Republic Rubber Corporation, Youngstown, O., has reconsidered and decided to remain. Mr. Jones formerly had been president and general manager of the Elyria Iron & Steel Co., Cleveland, and at one time was president and general manager of the Clinton-Wright Wire Company, Worcester, Mass., now part of the Wickwire-Spencer Steel Corporation.

✓ ✓

C. F. Blackmer, assistant superintendent American Steel & Wire Co., plant at Waukegan, Ill., has been appointed superintendent of the new wire mill which is being constructed in connection with the Minnesota Steel Company plant at Duluth, Minn. Mr. Blackmer will leave Waukegan May 1, to take charge of the construction of the new mill, which will take about a year.

✓ ✓

Charles Major, for many years president of the A. & P. Roberts Co., now known as the Pencoyd Iron Works of the American Bridge Company, Pencoyd, Pa., has retired after 41 years continuous service at that plant, and on Saturday evening, March 26, was tendered a testimonial dinner in Philadelphia by his associates. There were also a number of guests. Percival Roberts, Jr., of the board of directors of the United States Steel Corporation and Charles Belsterling of the legal department of the corporation, who was formerly traffic manager of the Pencoyd works, were the principal speakers.

✓ ✓

C. E. Dinkey, until a year ago general superintendent of the Edgar Thomson Works of the Carnegie Steel Company, has been made president of the Morrison, Dinkey & Todd Co., a recently organized firm of bond and security brokers, with headquarters in the Diamond Bank Building, Pittsburgh.

John A. Baker, formerly with the Mesta Machine Company, Pittsburgh, as assistant general superintendent, has been appointed works manager for the Los Angeles plant of the Rich Steel Products Company.

✓ ✓

G. Conway Shackelford has resigned as consulting engineer of the Republic Iron & Steel Co., Youngstown, O., after serving the company for 14 years. He is succeeded by Stanley M. McKee, his assistant, who assumes the title of chief engineer. Mr. Shackelford will return to his old home in Virginia, where he has purchased a large stock farm and will enter into stock-raising. Prior to his connection with the Republic Company, he served in engineering capacities with the United States Steel Corporation. As chief engineer of the Republic Company, he supervised the plans for the Lansingville plant at Youngstown.

✓ ✓

W. W. Runyan, who has been superintendent of operation of the Neville Island Ordnance Storage Depot and who previously was associated with the Whitaker-Glessner Company, both in an operating and a sales capacity at Portsmouth, O., has joined the sales force of Max Solomon, scrap iron and steel, Oliver Building, Pittsburgh. Mr. Runyan was district sales representative of Whitaker-Glessner Company at Atlanta, Ga., and also represented the company in the Southwest, with headquarters at Kansas City, for one year. For the past three years he has been connected with the ordnance department, first with the Pittsburgh district ordnance office and, after the signing of the armistice, with the Pittsburgh district salvage board.

✓ ✓

D. W. Pitcock resigned as superintendent of the Masillon Rolling Mill Company on April 6, a position he occupied for seven years.

✓ ✓

George W. Reese for 30 years superintendent of the steel foundry of the Lorain Steel Company, Johnstown, Pa., has resigned.

✓ ✓

W. C. Bates has severed his connection with the Standard Engineering Works, Ellwood City, Pa., and located in Pittsburgh.

WITH THE EQUIPMENT MANUFACTURERS

COMBINATION PNEUMATIC PUNCH AND RIVETER

A new machine manufactured by the Baird Pneumatic Tool Company of Kansas City, Mo., which can be used either as a punch or riveter simply by changing the dies, has recently been put on the market.

Among the many advantages of this machine is the fact that although it is a stationary unit, it can be readily be moved from place to place in the plant where the work is located as it weighs only 600 pounds complete.

It has a capacity for punching $\frac{5}{8}$ -inch plate and for riveting $\frac{3}{8}$ -inch cold rivets and because of this dual use is particularly adaptable for light structural steel fabrication. In a recent test in the plant of one of the largest and most efficient manufacturers in America, this machine with two operators did the work heretofore accomplished by eight men using pneumatic hammers, and did the work better.

The pressure exerted on the punch and rivet dies is approximately 70,000 pounds. It operates on the standard air line pressure of 100 pounds.

BELLEVUE ANNEALING FURNACE.

A late type of annealing furnace developed by the Bellevue Industrial Furnace Company, Detroit, Mich. The furnace is of the semi-muffle type and can be heated by either oil or gas. It is equipped with a hand-operated chain mechanism for raising or lowering the door, the weight of the door being suitably counter-balanced. Two of the company's standard oil-burners are ordinarily used for heating the furnace and are located at the front, where they are easily available for adjustment. The gas burners can be substituted if desired.

The furnace is built in six sizes, the muffles being from 56 to 78 inches wide, 60 to 120 inches deep, and 8 to 24 inches high, the dimensions of the minimum and maximum sizes being given.

QUICK-ACTING STEAM DROP-HAMMER.

A line of quick-acting steam drop-hammers of small sizes has been developed by the Massillon Foundry & Machine Co., Massillon, O., for use on light work. These hammers are built in sizes of 400, 600 and 800 pound capacity, but other sizes can be built to meet special requirements. The hammers can be operated by compressed air in place of steam, if so desired. The housings and base are steel castings and the cylinder is a semi-steel casting. The company has incorporated in these small hammers its design of adjustment for the ram guides that was originally brought out on hammers of larger size, to permit of the ready removal of damaged push-bolts. The guide adjusting screws are threaded through nuts set in open pockets in the side housings.

THE NEW BROWN RECORDING THERMOMETER.

Sixty years' experience in instrument making stands back of this New Brown Recording Thermometer. It is different from any other thermometer manufactured, in that it incorporates the latest constructional advantages such as:

Pen Arm Adjustable—The pen arm is completely adjustable with set screws for "set" and "tension."

Calibrating Means—The helix is adjustable for calibrating.

Moisture-Proof Case—Every instrument is supplied with a moisture-proof case as standard equipment and at no additional cost.

Automatic Pen Release—Lifts pen automatically when door is opened.

Patented Chart Clips—Automatically lock the chart when the door is closed.

Seth Thomas Clock Eight-Day Movement—Attached to front plate, so that clock must at all times be in alignment



New Brown Recording Thermometer.

with chart, and can be removed, if necessary for cleaning in two minutes.

Many charts for ranges from minus 40 degrees F., to plus 1000 degrees F., are carried as standard equipment.

And you will notice from above illustration, the design of this new thermometer, the servicable black enameled case and ring, the open graduations on the chart, the inverted pen arm, the heavy bronze reinforced tubing, the robust bulb, and heavy threaded union connection.

Every detail in the design of this new thermometer has been perfected after years of experience, and a close study of practical conditions. This instrument spells "quality" in every detail. No expense has been spared in manufacture.

For further information regarding this new thermometer, address, The Brown Instrument Company, Wayne Junction, Philadelphia, Pa.

NEW ELECTRIC ANNEALING FURNACE.

The Electric Furnace Construction Company, 908 Chestnut street, Philadelphia, announces an order from the Sociedad Espanola de Construccion Naval, Madrid, Spain, for a new design of electrically heated car type annealing furnace for heat treatment of large steel ingots and forgings. The furnace is stated to be the largest electric furnace in the world for this particular class of work. The dimensions are 6,800 mm long by 4,750 mm wide by 4,140 mm high, and will heat a charge of 60 tons of steel to 1,700 degrees F. every 24 hours. The Electric Furnace Construction Co. has already supplied the same company with an electrically heated furnace 36 feet deep by 12 feet outside diameter for heat treatment of gun and large forgings. The heat regulation on both furnaces is automatic and a pre-determined heat of within 5 degrees plus or minus it is claimed can be secured.

TRADE NOTES

The Conveyors Corporation of America, Chicago and New York, take pleasure in announcing the appointment of Mr. Robert B. M. Wilson as sales engineer of the Chicago district. With him will be associated as an assistant, Mr. E. M. Wolfe. Headquarters will be maintained in the corporation's main office at 326 West Madison street.

The sales management for Riley Underfeed Stokers and Murphy Furnaces has been concentrated under one head. Mr. William Pestell, formerly Western sales manager with headquarters at Chicago, now becomes sales manager with headquarters at 1226 Woolworth Building, New York City. Mr. W. L. Bigelow becomes district manager of the Pittsburgh territory, while Mr. C. Lincoln Smith goes to Cincinnati in the same capacity.

To better serve the territory in and around Kansas City, the F. M. Beeson Machinery Company, 308 Mutual Building, Kansas City, Mo., have been appointed sales agents for both Riley stokers and Murphy furnaces. Sales in Denver territory will be handled by Stearns-Roger Manufacturing Company, 1718 California street, Denver, Colo. The Boston, Buffalo, Cleveland, Detroit, Chicago and St. Paul offices remain as heretofore.

Arthur G. McKee & Co., engineers and contractors, Cleveland, have received an order from the Carnegie Steel Company, covering the furnishing of a McKee revolving distributor and new gas seal for their "I" furnace at the Edgar Thomson Works, Braddock, Pa.

Theodore S. See and Henry W. Seldon have organized the firm of See-Seldon and Associates—Industrial and Combustion Engineers and announce the opening of their offices in the Oliver Building, Pittsburgh. Their services are now available as consulting and operating engineers.

At the last meeting of the board of directors of F. J. Ryan & Co., Franklin Trust Building, Philadelphia, specialists in electro-thermic engineering, the following elections to the board of directors took place: Mr. W. W. Posey, president of the Lancaster Iron Works was elected as a director. Mr. A. C. Sculley, secretary and treasurer of the Lancaster Iron Works was elected as a director and treasurer.

The Electric Furnace Company, Alliance, O., has just installed three Baily electric brass melting furnaces of different size and capacity but built upon the same resistance principle. The Bagley & Sewall Co., Watertown, N. Y., has installed a 50 kw electric furnace with 500 pounds hearth capacity, the Alliance Brass & Bronze Co., a 75 kw furnace

with 800 pounds capacity, and the Empire Brass Works of London, Ontario, a 106 kw furnace of 1,500 pounds hearth capacity. All of these furnaces are to melt yellow and red brass alloys. The Empire Brass Works is the fourth Canadian plant to adopt the Baily electric furnace for melting its non-ferrous metals.

The Lorain Steel Company, Johnstown, Pa., is installing a 200 kw Baily electric furnace for heat treating railroad bolts and similar parts. The furnace is of the continuous pusher type with motor operated control mechanism. It will have a capacity sufficient to heat treat 14 tons of material per day. Installations of electric heat treating furnaces are rapidly increasing in plants which supply the railroads with equipment. Baily electric furnaces are being employed to treat such products as railway axles, draw bar knuckles, bolts and similar castings and parts.

Victor T. Goggin, late New England sales manager of Fred T. Ley & Co., Inc. of Springfield, Boston and New York, has severed his connection with that concern to associate himself as contracting engineer with Dwight P. Robinson & Co., Inc. of New York, Chicago, Dallas, Youngstown, Los Angeles and Montreal.

Mr. Russell B. Reid, for several years past with Edw. R. Ladew Company, as assistant sales manager, has been made manager of sales for the Sharon Pressed Steel Company of Sharon, Pa., manufacturers of motor car frames, industrial trucks and pressed steel automobile parts. Mr. Reid will direct the sales of the company from the New York office at 66 Broadway.

Mr. C. F. Herington, who has been connected for the past five years with the Bonnot Company, as mechanical engineer and district sales manager in Chicago, is resigning May 1, to accept a position as vice president of the Holbeck Engineering Company, Cleveland, Ohio.

Effective March 1, 1921, the name of Locomotive Superheater Company has been changed to The Superheater Company.

TRADE PUBLICATIONS

The fourteenth annual edition of "Metal Statistics" just issued, contains the same general assortment of statistical information concerning ferrous and non-ferrous metals that has been supplied in previous years, but various new tables have been introduced which it is hoped will further increase its usefulness to the trade. The aim each year is to furnish statistics which provide the information most generally required by the buyers of metals and iron and steel products. The book is for sale by the

American Metal Market and the price is one dollar.

"Are Mechanical Stokers a Good Investment?" is the title of a recent publication of the American Engineering Company. It dwells at length on the investment side of the stoker proposition and is full of authentic and definite facts.

"The Open Hearth," a book full of steel plant design and operation has been issued by the Wellman-Seaver-Morgan Company. It covers data obtained by this company throughout its entire existence. It is decidedly the foremost steel plant book of the year. It is to be sold for six dollars per copy.

"Lillie Evaporators for Waste Waters and Solutions Generally," is the subject of Bulletin 114 published by the Wheeler Condenser & Engineering Co., Carteret, N. J., manufacturers of the Lillie Evaporators. In it are described in considerable detail the features peculiar to the Lillie Evaporator and several installations for sugar work, distilling water, and for evaporating many kinds of chemicals, solutions and waste waters. A perspective diagram is also given of the triple-effect and auxiliaries recently installed at the power station of the Chile Exploration Company, Tocopilla,

Chile. A free copy of this bulletin will be sent to responsible persons upon mentioning this publication.

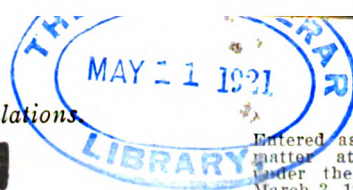
The Hercules Powder Company are responsible for a very interesting book entitled "Modern Road Building and Maintenance." It is prepared for the use of engineers, contractors, road officials, students and all who are interested in the national and economic solution of the many problems connected with our public roads and the traffic they are required to carry. It is edited by Andrew T. Anderson, highway engineer, bureau of public roads, U. S. Department of Agriculture. It would be of especial interest to all steel companies where it is necessary to build roads.

An up-to-date Technical Book Review Index dated December, 1920, has just been issued by the Technology Department of the Carnegie Library of Pittsburgh. This index is a record of certain book reviews appearing in technical and trade journal. The price of the index is fifty cents.

An interesting booklet on "Transportation, the Problem of Soft Coal" has been issued by the National Coal Association. It was published in an endeavor to obtain even distribution of output so the railroads will not be jammed under strain demand.

A reprint of H. D. Savage's paper on "Powdered Coal Application to Four 2,640 hp Boilers," which was presented before the mechanical section of the Engineers Society of Western Pennsylvania has been issued by the Combustion Engineering Corporation.

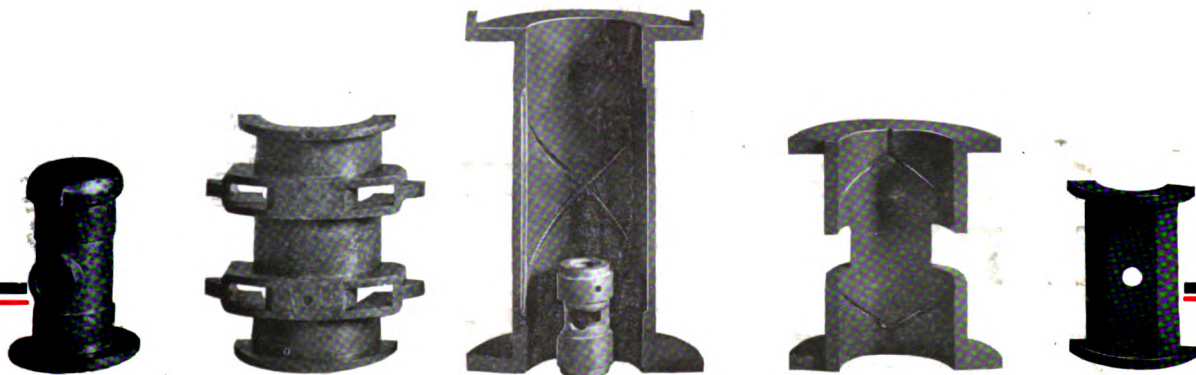
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